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# PROCEEDINGS: SEED COLLECTION WORKSHOP



MAY 16-18, 1979



U. S. Department of Agriculture – Forest Service – Southeastern Area – State & Private Forestry

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Seed Collection Workshop\*

MAY 16-18, 1979

MACON, GA.

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Seed Collection Workshop  
Macon, Georgia  
May 16-18, 1979

May 16--Field trip to Arrowhead Seed Orchard

8:30 Organize at the Farmer's Market, Macon  
9:00 Leave for Arrowhead Seed Orchard  
10:00 Arrive at Arrowhead Seed Orchard  
10:00-10:30 Demonstration of net collection system--John Brannon (GFC)  
10:30-11:00 Demonstration of binocular procedure for estimating cone crops--Ron Wasser (VDF) and Bob Karrfalt (S&PF, SA)  
11:00-12:00 Practical exercise in estimating cone crops. Continue discussion on demonstrations.  
12:00 Lunch  
1:30 Leave for Eastern Tree Seed Laboratory  
2:30 Tour Eastern Tree Seed Laboratory  
4:00 Return to Farmer's Market and adjourn for the day.

May 17--Indoor session--Farmer's Market, Macon

8:30 Cone maturation in southern pines--Clark Lantz (S&PF, SA)  
9:15 Fruit maturation in hardwoods--Frank Bonner (SEFES)  
10:00 Break  
10:15 Cone harvest of eastern white pine--Ed Manchester (USFS, R8)  
10:45 Refinements on vacuum seed harvesting--Jim McConnell (USFS-R8)  
11:15 Seed testing applications in harvesting--Bob Karrfalt (S&PF, SA)  
11:45 Lunch (on your own)  
1:00 Demonstrations  
A. Cone maturity-Seed Testing--Bob Karrfalt (S&PF, SA)  
B. Fungus isolations--Tom Miller (SEFES)  
2:00 Estimating loblolly pine cone crops--Ron Wasser (VA Div. of Forestry)  
2:30 Planning the harvest of certified seed lots--Earl Belcher (S&PF, SA)  
3:00 Break  
3:15 Slash pine cone storage containers--Homer Gresham (St. Regis Paper Company)  
3:45 Storage and transport of cones and fruits--Earl Belcher (S&PF, SA)  
4:15 Adjourn for the day

May 18

9:00 Potential pathogenic damage from harvesting in pine seed orchards--Tom Miller (SEFES)  
9:30 Announcement and discussion of fungal survey  
10:00 Break  
10:15 Course evaluation  
11:30 Discussion and question period  
12:00 Adjourn

## FRUIT MATURATION IN HARDWOODS [ J

F. T. Bonner

Abstract.--Successful collection of seeds of southern hardwoods can be enhanced by a knowledge of the natural sequence of fruit maturation. Seeds should not be collected until easily recognized maturity indices are apparent. Artificial ripening of premature collections is possible with some, but not all, species.

✓ Additional keywords: Liquidambar styraciflua, Liriodendron tulipifera, Platanus occidentalis, Fraxinus, Quercus, [seed collection] chemical contents.

The maturation processes of hardwoods differ from those of pines, and their fruits require different methods of handling. Since the timing and manner of fruit or seed collection often can be crucial, an understanding of fruit maturation in hardwoods is necessary to meet deadlines and achieve best results.

Among hardwoods, single-seeded fruits (oaks, ash, water tupelo, and so forth) are distinguished from multiple-seeded fruits (sycamore, sweetgum, yellow-poplar, and so forth). As an example of each, I have chosen yellow-poplar for multiple-seeded fruits and water oak for single-seeded fruits.

### Sequence of Maturation

In the Midsouth, yellow-poplar fruits reach full size by July. From July until seed maturity in October or November, fruit fresh weight and moisture content decrease slightly, and dry weight remains constant. Specific gravity of fruits declines steadily from about 0.85 in July to 0.65 or lower at maturity (Fig. 1).

Even though fruits get no larger after July 1, seeds inside continue growing. Their endosperms are in a liquid state early in this period and thicken through July and August. Soluble forms of nitrogen compounds are converted to proteins, and soluble carbohydrates are converted to insoluble storage carbohydrates.

These conversions to insoluble forms of storage reserves, either fat or carbohydrate, continue to the time of seed dissemination. Seeds reach germination capability before this time, however, which indicates that the accumulation of storage foods in the endosperm is not necessarily a prerequisite for physiological maturity of the embryo. Yellow-poplar seeds will germinate and produce normal seedlings as early as late September in the Midsouth, more than a month before storage food accumulation is complete (Bonner, 1976). In natural seed dissemination and germination, seeds with the most stored food should have a competitive advantage.

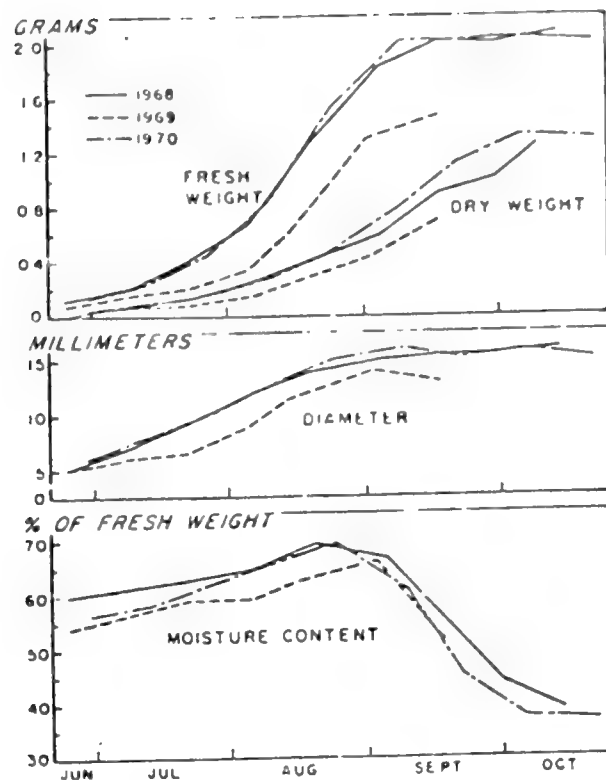


Figure 1.--Seasonal changes in fresh weight, dry weight, specific gravity, and moisture content of yellow-poplar fruits (from Bonner, 1976).

In contrast, the single-seeded fruit of water oak increases in size and weight from late June until late September or early October (Fig. 2). Moisture content reaches a peak in late August, then declines rapidly.

Chemical processes which occur in maturing acorns are similar to those in yellow-poplar. Soluble materials are converted to insoluble forms of storage foods. Fats and carbohydrates, the main storage reserves in acorns, begin a sharp increase in early September. This rise ends at acorn maturity in late October (Fig. 3).

Acorns picked in advance of full maturity will not produce normal seedlings. While storage foods are being accumulated, other necessary biochemical substances, possibly growth regulators, are being produced or accumulated in the seed. Collecting acorns before these unknown processes are completed leads to failure.

#### Indices of Maturity

When are these fruits ready to pick? After 10 years researching this question, I find that the best answer for southern hardwoods is still fruit color. For sweetgum, sycamore, yellow-poplar, and green ash, wait until the dark, green "vegetative" color in the fruits fades to a greenish-yellow or yellow. For acorns, collections should be delayed until the green color fades to brown or black. In white oak, a mottled yellow-brown usually is acceptable. For acorns, a second test should be used: collect only when

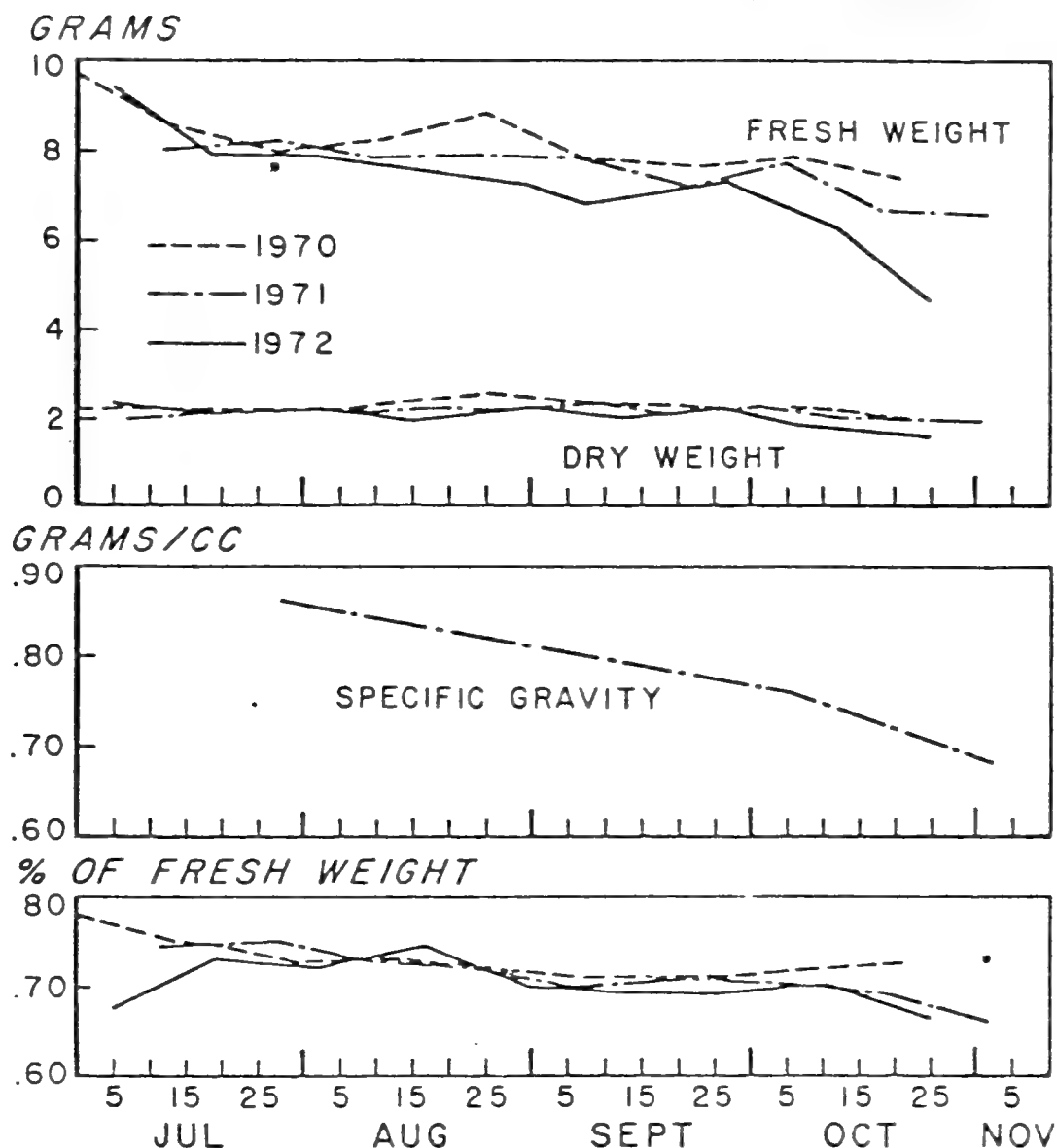


Figure 2.--Seasonal changes in fresh weight, dry weight, diameter, and moisture content of water oak acorns (from Bonner, 1974).

they slip easily from their cups without pressure. The cup scars should be bright, not dull or dark.

Drupes or other fleshy fruits also show a significant change in color at maturity. Black cherry in the south should be reddish-purple or purple when collected (Bonner, 1975). Water tupelo should be dark purple.

Specific gravity testing of hardwood fruits has met with little success. Sweetgum and sycamore fruits change little during the maturation period (Bonner, 1972), and acorn specific gravities have not shown consistent patterns. Only for yellow-poplar cones, which show specific gravities near 0.6 at maturity (Bonner, 1976), has there been any chance of success. But even with this species, color change is still the best test.

Chemical indices of hardwood fruit maturity are possible for most species, based on the accumulation of storage reserves, such as crude fats in water oak (Fig. 3). With current levels of demand in the South, however, the use of chemical indices is not justified.



### MG/G SEED

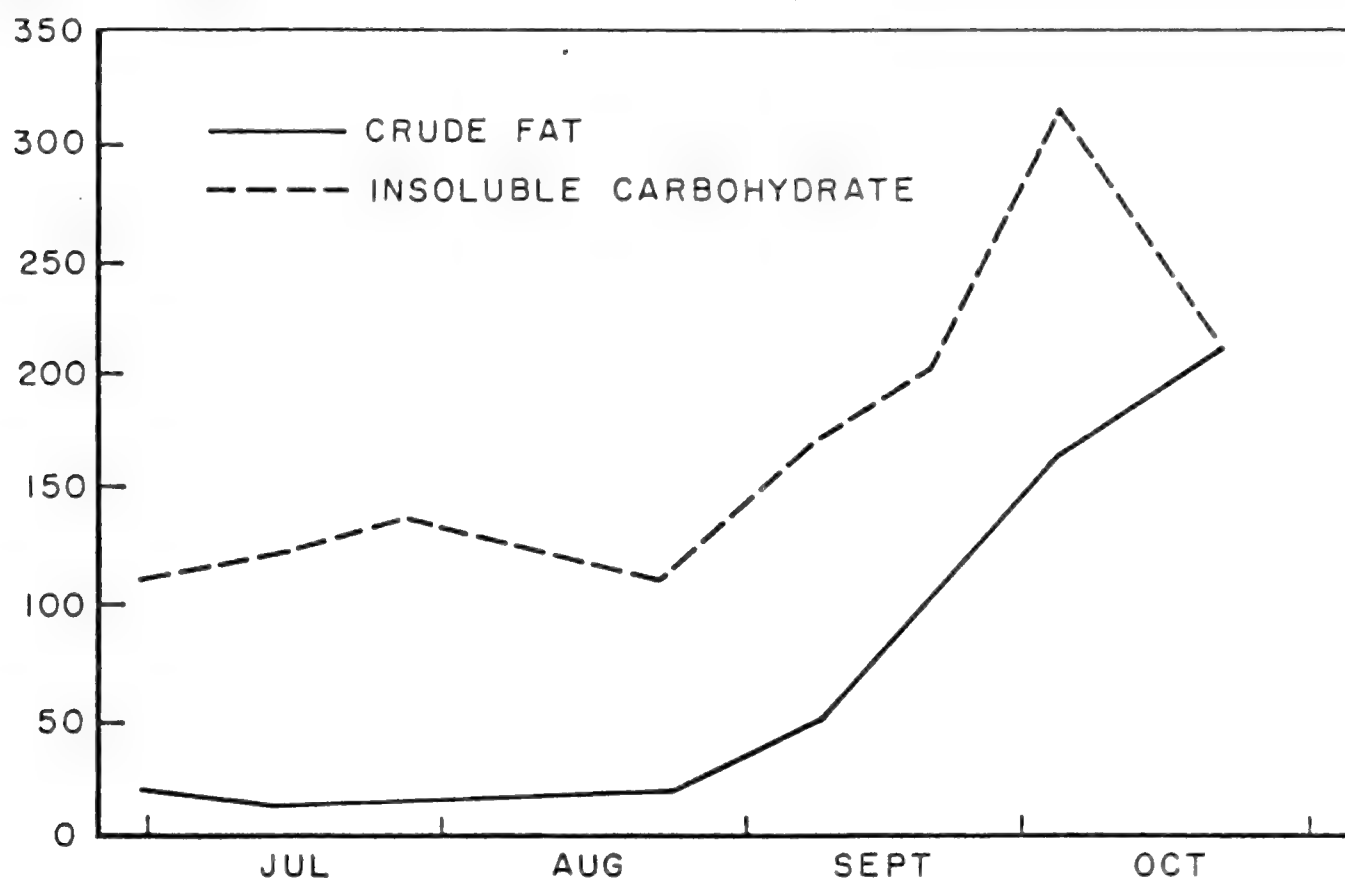


Figure 3.--Seasonal changes in crude fat and insoluble carbohydrates of water oak acorns (from Bonner, 1974).

When collections are made as early as possible, perhaps before full seed maturity, fruits and seeds will have high moisture contents. The green color is a sure sign of high moisture content in fruits. Under these conditions, special handling is required to avoid overheating. Multiple-seeded fruits should be spread in shallow layers, preferably with air movement above and below, for slow drying. Green fruits should not be left in piles or containers longer than overnight. Acorns should be kept cool and moist, preferably in a refrigerator.

In sycamore, the loss of green fruit color is also a good index of maturity. However, since sycamore fruits persist on trees well into December or January, they can be collected after all other species, without any decrease in seed quality.

#### Artificial Ripening

One technique for increasing the harvest period is artificial ripening of premature collections, tested successfully 20 years ago on western conifers. This method also has been successful in artificially ripening sweetgum (Bonner, 1970) and, to a lesser degree, yellow-poplar (Bonner, 1976).

Multi-seeded fruits might be ripened if all required substances were in the fruit and need only be translocated to the seeds, and such seems to be the case. Holding these fruits in a cool, moist environment (3° to 5° C in damp moss) allows this translocation to occur. A study conducted in 1967-68

in north Mississippi showed that sweetgum fruit heads could be collected about one month earlier than usual. Seed yields were reduced only 20 percent, and germination was reduced hardly at all (Bonner, 1970). In yellow-poplar seeds, cool, moist storage of cones increased germination capacity in most cases and stimulated initial germination by 4 to 10 days (Bonner, 1976).

Acorns should be left on trees until fully mature. Because essential nutrients or growth factors are translocated into acorns until maturity, artificial ripening will not work. Research in north Mississippi on artificially ripening acorns of several oak species and green ash gave negative results.

Under normal conditions, artificial ripening of premature collections of hardwood fruits has little use. Under severe time or geographic limitations, however, it could be used to get small quantities of seeds from collections that otherwise might not be made.

#### Summary

To obtain successful collections of hardwood fruits and seeds:

- (1) Know the natural sequence of fruit maturation of the species to be collected.
- (2) Collect only after the green color fades in fruits; for acorns wait until they also slip from the cups easily.
- (3) Beware of high moisture levels in fruits: spread them to dry as soon as possible.
- (4) Use artificial ripening for early collections of multi-seeded fruits only in abnormal circumstances.

#### Literature Cited

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## SOUTHERN PINE CONE MATURATION AND STORAGE [ ]

James P. Barnett <sup>1/</sup>

Abstract.--Loblolly and slash pine cones can be collected 2 or 3 weeks before their specific gravities reach 0.89, if they are held 3 to 5 weeks before processing and if reductions in yield and viability are acceptable. Longleaf cones should be collected only when mature, since storage decreases germination of seed from immature cones. Extended cone storage, either outdoors or under cover, is possible with loblolly and slash pine, but seeds from shortleaf cones held for long periods in the open are less vigorous. To minimize seed injury, cones should be processed in this order: longleaf, shortleaf, slash, and loblolly pine.

Additional keywords: *Pinus*, longleaf pine, slash pine, loblolly pine, shortleaf pine, [germination, seed quality]

Because of increasing tree size in large acreages of producing southern pine seed orchards, cone collection has become steadily more difficult. Extending the normal 2- to 3-week cone harvest period could ease problems facing seed orchard managers. Generally, southern pine cones have been considered mature and ready for harvest when their specific gravities drop below 0.89 (Wakeley 1954). However, many cones with specific gravities in the 0.80's will caseharden when kilned without precuring. Several studies (Bevege 1965, McLemore 1975, Waldrip 1970) have shown that extending the collection period is possible if slightly immature cones are stored before kilning. Tests conducted in central Louisiana indicate that these early cones can have acceptable seed yields and can maintain seed viability during extended storage.

## METHODS

Four trees each of loblolly (*Pinus taeda* L.), slash (*P. elliottii* Engelm. and longleaf (*P. palustris* Mill.) pine were selected in central Louisiana. Twenty-four cones were collected at intervals from each tree to test cone and seed maturity. Each lot of 24 cones was divided into four groups of six each. One group was tested for specific gravity immediately after collection, and each of the other three groups received one of three storage treatments to determine whether cones would ripen artificially. The cones were stored in open paper bags in an unheated building for 1, 3, and 5 weeks before processing. Cones were opened by drying for 3 days in a gas-fired kiln at 100° F.

In addition, cones from four trees each of loblolly, slash, and shortleaf (*P. echinata* Mill.) were collected to evaluate effects of cone storage on seed quality. All cones from each species were composited, and three replications were drawn to test 0-, 30-, 60-, 90-, 120-, and 150-day cone

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storage in the open and under a shed. The cones were held in burlap bags on wooden pallets. Similar tests are underway with slash pine that also compare burlap bags and 20-bushel wooden boxes for storage. The effects of the treatments on seed quality were tested initially and after 1 year at 72° F. Seeds were dried to about 10 percent moisture content and stored in sealed polyethylene bags.

Seed yield determinations were made by counting seeds released after kilning. Germination tests were conducted on 100 percent sound seed with a minimum of 100 seeds per treatment replication. Where yields were insufficient for germination tests, cones were forced open to obtain seeds. Slash, longleaf and shortleaf seeds were tested without stratification; loblolly seeds were stratified 28 days before testing.

## RESULTS AND DISCUSSION

### Loblolly Pine

Loblolly pine cone collections normally begin in early October when specific gravity is about 0.89. In 1969 cones reached maturity near October 1 (Figure 1). In September, average number of seeds per cone tended to increase with subsequent collections and with increasing lengths of cone storage (Figure 2). Storage had much less effect when cones were collected in October, when they were considered mature. Cones collected as early as September 15 (specific gravity 0.99) and stored 5 weeks yielded 38 seeds per cone, compared to 47 per cone for the final collection (specific gravity 0.80), stored 3 weeks.

One week of storage for collections made in September yielded few seeds, with the exception of the September 22 collection when more than 20 seeds per cone were extracted. Cones collected on September 29 (specific gravity 0.88) yielded only one seed per cone after 1 week of storage. During October, yields after 1 and 3 weeks of storage increased appreciably, and yields of seeds stored 3 weeks were superior to those of seeds stored 5 weeks.

Germination was 95 percent or greater for all dates of collection and for all storage periods (Figure 2). Obviously, collections were not begun early enough to allow observations of seed development: loblolly seeds apparently mature several weeks before cones are ripe enough to open fully.

These results were confirmed by the 1970 loblolly tests, when collections were begun 5 weeks earlier and storage was omitted. Seed yields were nil through September 21 but satisfactory thereafter. No viable seeds were found in the August collection; the germination rate was 58 percent for the seeds collected on September 7, 79 percent for those collected on September 21, and 96 percent for those of October 5.

These results indicate that collections can begin 2 or 3 weeks earlier than normal, if some reduction in yield and viability is acceptable and if cones are stored 3 to 5 weeks before processing.

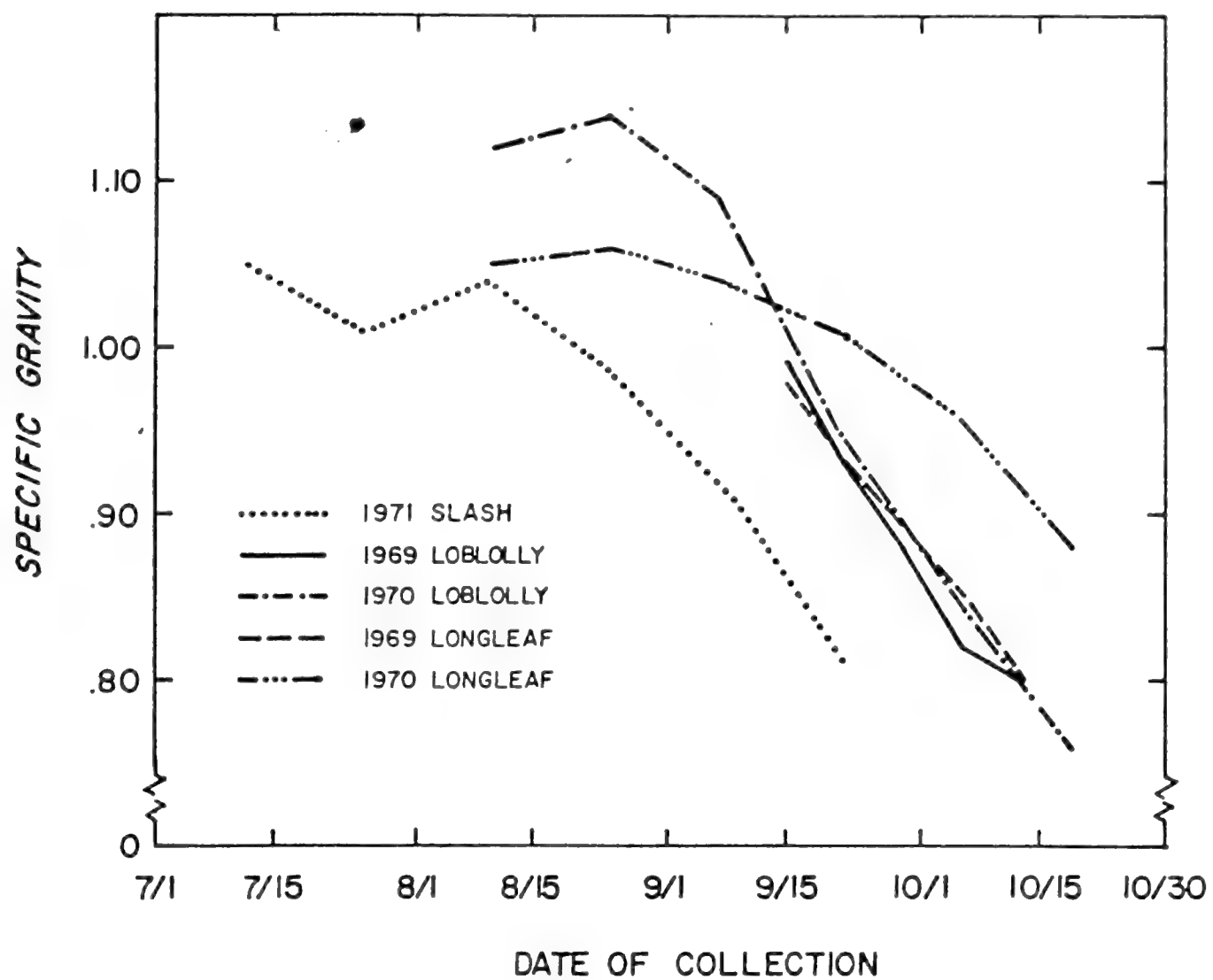


Figure 1.--Specific gravities of loblolly, slash, and longleaf pine cones at different dates.

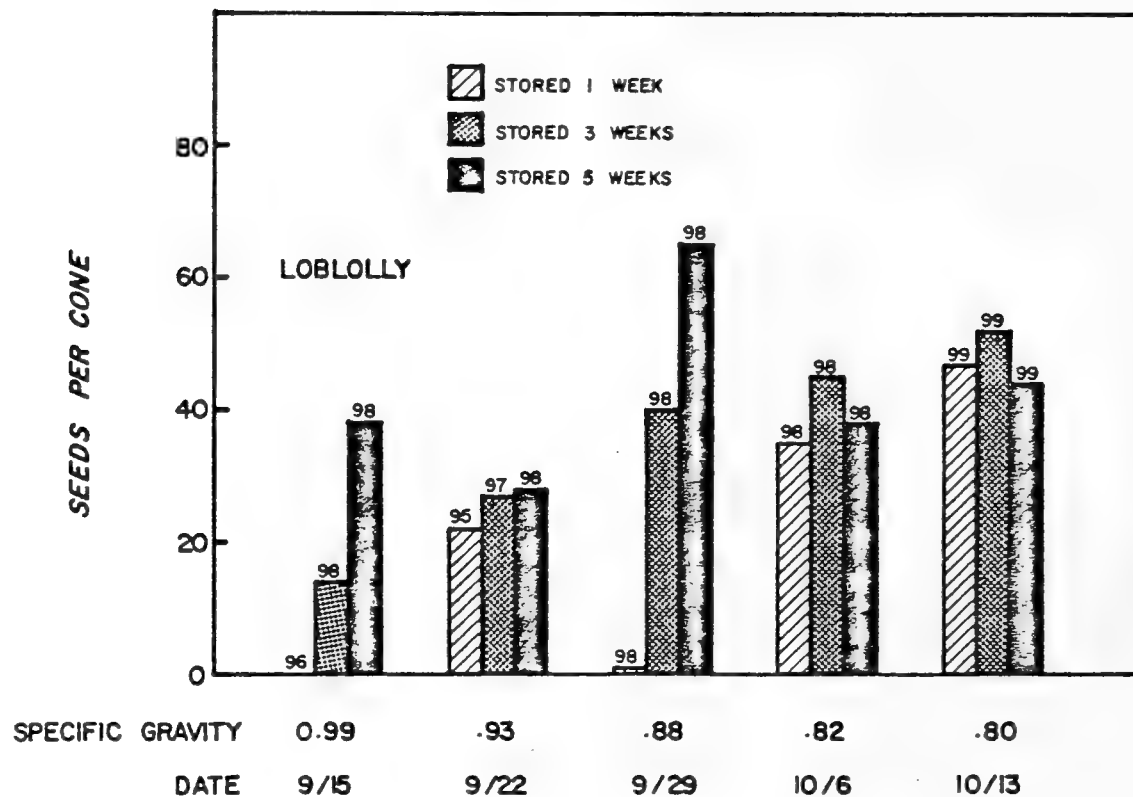


Figure 2.--Seed yields and germination (shown above bars) of loblolly pine as affected by date of collection and cone storage (1969).

Effects of prolonged storage in the open and under cover on seed quality also was tested. Cones were placed in burlap bags and held both in the open and under a shed for periods up to 5 months before processing. Overall germination of seeds was better from cones held in the open than from those held under cover, but no differences appeared during the first 60 days (Table 1). Length of storage had no effect on viability when cones were exposed to open conditions for up to 150 days. Viability of seeds from cones held under a shed for 90 days or more dropped about 20 percentage points. Evaluations of speed of germination indicate that seeds from cones held in the open were less dormant and may have received some stratification effect from outdoor conditions.

Little loss of viability occurred when seeds were stored for 1 year at 72° F. This high temperature was chosen to accelerate deterioration and to accentuate treatment differences. However, average loblolly seed viability from the shed and open cone storage treatments dropped only 2 and 7 percentage points, respectively. These results indicate that loblolly seeds can take considerable abuse before germination is affected.

Table 1.--Germination of loblolly, slash, and shortleaf pine seeds extracted from cones held in burlap bags under a shed and in the open

Storage :Days of:		Initial germination		:Germ. after 1 yr. at 72° F			
condition	:storage:	Loblolly:	Slash	:Shortleaf:	Loblolly:	Slash	:Shortleaf
-----Percent-----							
Shed	0	98	98	96	90	93	95
	30	97	98	96	91	88	90
	60	92	93	90	89	86	80
	90	79	91	65	83	83	73
	120	76	90	85	80	82	94
	150	89	90	81	86	91	86
Open	0	95	97	96	93	90	86
	30	99	97	95	88	90	86
	60	95	97	95	90	88	75
	90	97	95	90	89	85	71
	120	98	94	95	92	92	88
	150	96	90	90	90	89	76

#### Slash Pine

Slash pine collections usually begin in early September. In 1971 maturity occurred before September 15 (Figure 1) and collections were begun 8 weeks before maturity. Seed yields generally increased with subsequent collections and longer cone storage. Cones collected in late August gave acceptable yields, provided the cones were held 5 weeks before processing (Figure 3). When cones were held 5 weeks, seed yields from the August 23 collection (specific gravity 0.99) were 70 per cone. Yields were 85 per cone when picked on September 22 (specific gravity 0.81) and held 5 weeks.

Germination was never high; the best rate (83 percent) was for seeds from cones collected September 22 and held 5 weeks. No seeds from cones picked in July germinated. Germination was low when cones were collected in early August, but it was acceptable when cones were collected in late August and held for 5 weeks.

Although yields usually are adequate by late August for cones with a specific gravity of 0.95, viability is lower than that for seed from cones about to open. To obtain maximum germination, cones must register 0.89 specific gravity when collected and stored.

The type (open or shed) of cone storage had no effect on viability (Table 1). However, as length of cone storage exceeded about 60 days, initial viability generally dropped 7 to 8 percentage points. Thirty- and 60-day cone storage increased the speed of slash germination.

Another collection of slash cones was made to obtain data on the effect of 1-bushel burlap bag and 20-bushel box storage containers (Table 2) <sup>1/</sup>.

<sup>1/</sup> The International Forest Seed Company cooperated by obtaining and storing the cones for this study.

This collection was made in 1978 when the crop in central Louisiana was very scarce and resulting seed yields were low (0.15 pound per bushel). Seed vigor also seemed low. Seeds in cones stored in burlap bags under cover seemed to mature after collection, probably reflecting collection before specific gravity reached 0.89. This maturation was not as apparent when storage was in the open, perhaps because seed vigor was low and deterioration offset any gain. However, at 4 months of storage, germination was 82 percent for both storage conditions. There seemed to be no difference in seed from the center of 20-bushel boxes and burlap bags when they were held under cover for 3 months or less. When boxes were held in the open, however, viability began dropping after 60 days. Although differences in type of container would be less apparent with more vigorous seed, these results indicate that processing of cones in 20-bushel boxes should begin within 60 days. Viability of seeds from cones in the center of open-stored boxes seemed to deteriorate faster than that of seeds from surrounding cones (Table 2). This difference may reflect the effects of mold and fungi growth in the inner areas of the boxes.

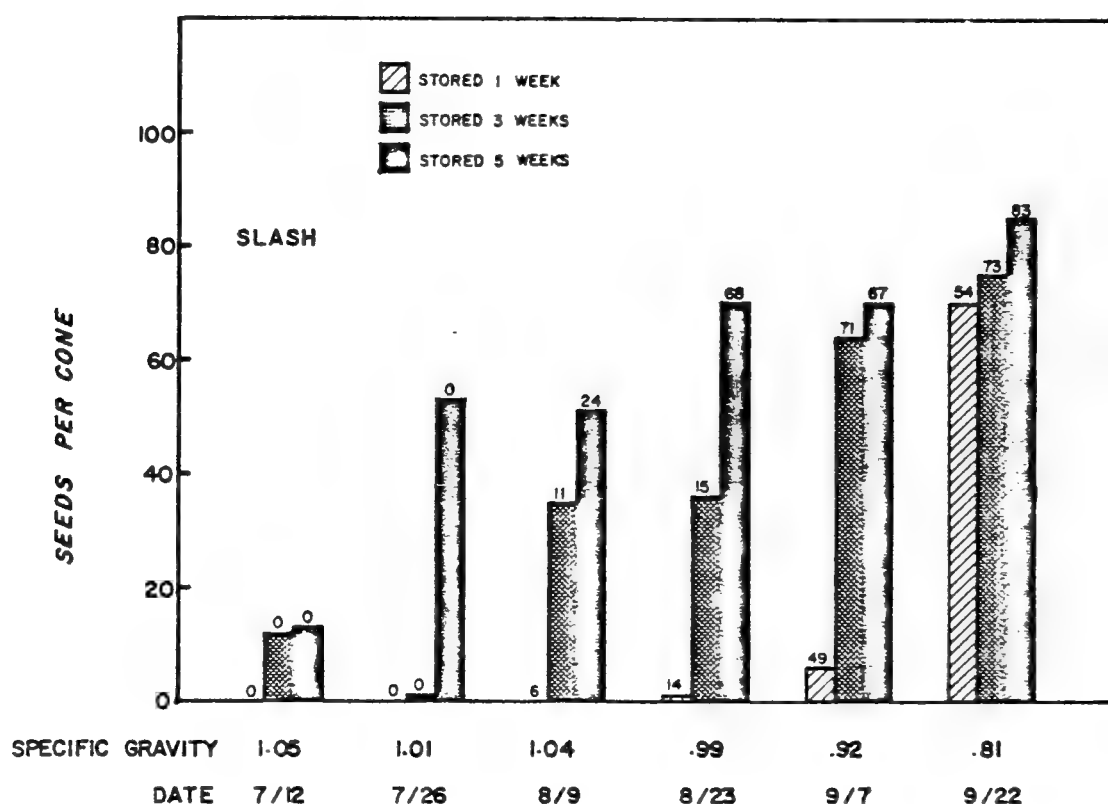


Figure 3.--Seed yields and germination (shown above bars) of slash pine as affected by date of collection and cone storage.



Table 2.--Germination of slash pine seeds extracted from cones held in 1-bushel burlap bags and 20-bushel boxes under a shed and in the open

Storage conditions	: Days of storage	: Burlap bag	: <u>Wooden box 1/</u>	
			Center	Outer
			<u>Percent</u>	
Shed	0	76	78	--
	30	87	86	--
	60	88	80	--
	90	76	79	68
	120	82	67	77
Open	0	73	80	--
	30	78	75	--
	60	76	71	--
	90	73	66	74
	120	82	62	80

1/ Cones were sampled primarily from the center of the 20-bushel boxes; however, on two occasions cones were sampled from outer areas of the boxes.

#### Longleaf Pine

Differences between cones collected in 1969 and 1970 showed that longleaf cones generally ripened later than loblolly cones, although differences in individual trees may account for some of the variation. Longleaf cones reached maturity on September 29 in 1969 but not until October 17 in 1970.

Yields of longleaf seed generally increased as the date of collection advanced, if cones were held for 3 to 5 weeks before kilning (Figure 4). Storing cones 5 weeks appreciably improved yields from all collections, except the one from October 6, for which 3-week storage was superior. The highest yields were obtained with cones stored 3 to 5 weeks, if the cones' specific gravity was 0.89 or below at time of collection. Yields for those collected earliest (September 15) and held 5 weeks were only about half those of later collections.

Overall, viability increased with successive collections. But for cones gathered in earlier collections, longer storage resulted in reduced germination. Seed collected October 13 was unaffected by cone storage. These results indicate that longleaf cones should be collected only when mature. Also they should be processed as quickly as possible because cone storage beyond 5 weeks results in reduced seed germination in storage (Figure 5).

The 1970 tests confirmed that cones collected and processed when specific gravity was above 0.90 failed to open adequately and release seed. Seeds were obtained only from the final cone collection (October 19), for which germination was 93 percent.

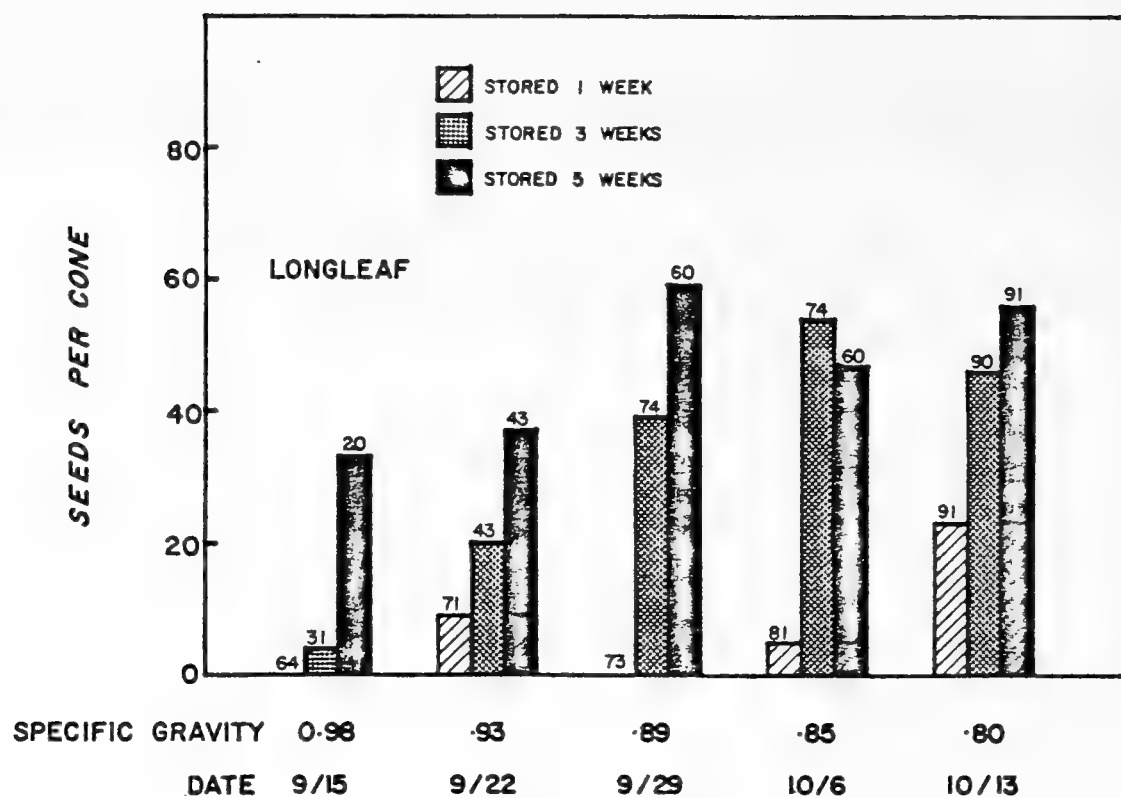


Figure 4.--Seed yields and germination (shown above bars) of longleaf pine as affected by date of collection and cone storage.

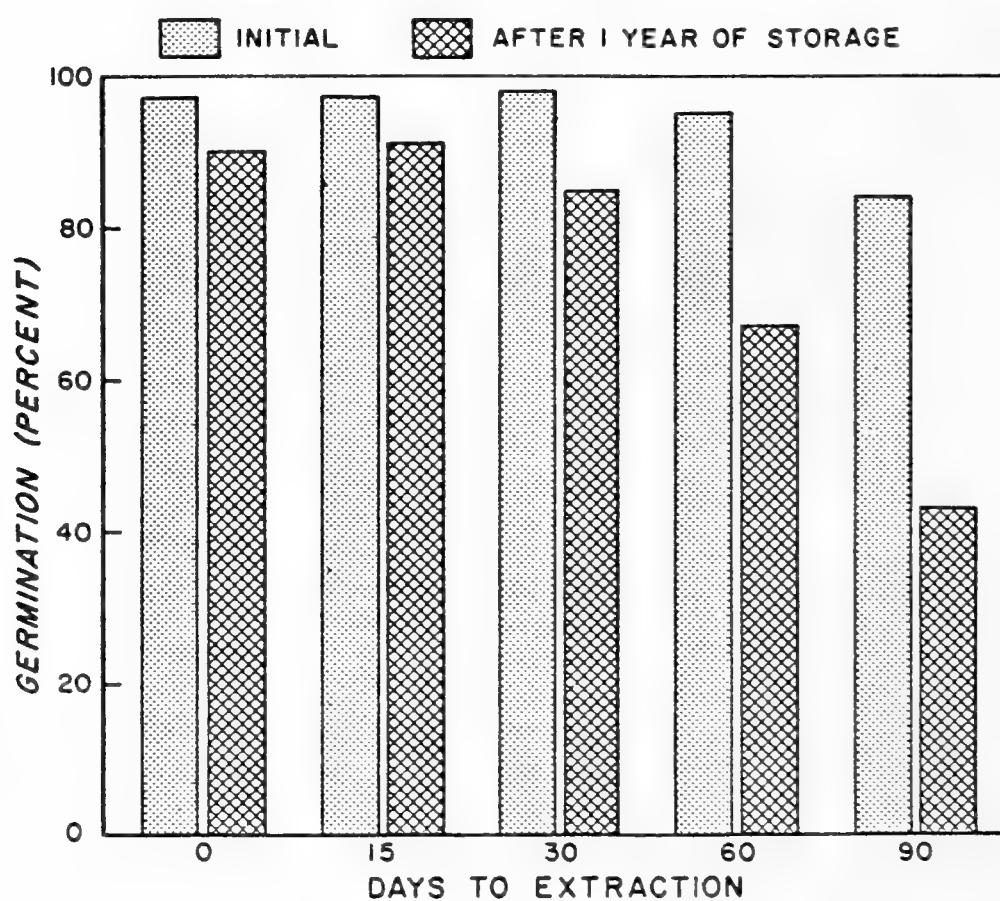


Figure 5.--Effects of delayed extraction on longleaf seed germination initially and after 1 year of seed storage. Adapted from McLemore (1961).

## Shortleaf Pine

Although my results include no detailed studies of the maturation of shortleaf pine, it appears to respond to cone storage similarly to loblolly pine (Table 1). Shortleaf cones held in the open germinated better than those kept under a shed. Some of this increase may be caused by stratification, since speed of germination increased markedly after open storage.

Results after seed storage for 1 year indicate that shortleaf seeds were harmed by outdoor cone storage more than either loblolly or slash pine.

## CONCLUSIONS

Optimum yields and germination are possible with loblolly and slash pine only if cones are mature when collected. Early collections seem advisable only if the cone crop is sizable and large quantities of seed are needed immediately, or if the labor supply is limited. When the cone crop is small, collections should be delayed until cones are fully mature. Starting collections about 2 weeks earlier than normal nearly doubles the harvest period, but it increases total seed yield only 25 percent because yield per cone decreases. Seed costs also increase substantially.

Collections of loblolly can begin 2 or 3 weeks before maturity if specific gravity is 1.0 or less (about mid-September), but yields may be only 30 to 40 percent those from ripe cones. Seeds from immature loblolly cones apparently are mature when cones are ripe for harvest. Slash cones can be collected up to 21 days before maturity (specific gravity 0.95) with a smaller loss in yield than with loblolly. Slash pine seeds continue ripening during cone storage, even if cones are mature when picked.

Because viability of seeds from immature longleaf cones decreases during storage, only mature cones should be collected. Once ripe, longleaf cones can be stored 3 to 5 weeks to increase seed yields without reducing viability, but storage should not exceed 5 weeks.

While extended cone storage is not desirable, with some species it can be done without adversely affecting seed quality. If cones are held for extended periods, burlap bags may cause fewer problems than 20-bushel boxes. However, this is also probably dependent on how the burlap bags are handled. Close stacking may result in conditions similar to those occurring in boxes. Loblolly and slash cone storage outdoors was as good as under a shed, but shortleaf cones held under cover yielded more vigorous seeds.

To minimize seed injury, processing in this order is recommended if cones of more than one species are collected: (1) longleaf, (2) shortleaf, (3) slash, and (4) loblolly pine cones.

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AN EASY WAY TO MEASURE CONE SPECIFIC GRAVITY [ ]

James P. [Barnett 1/

Abstract.--Specific gravity is the most reliable means of determining cone maturity in southern pines. Flotation in liquids of designated specific gravities has been the method customarily used. But fast and accurate measurements of cone specific gravities can be made using a graduated cylinder to determine cone weight and volume.

Additional keywords: Cone maturity, [*Pinus*, cone collection]

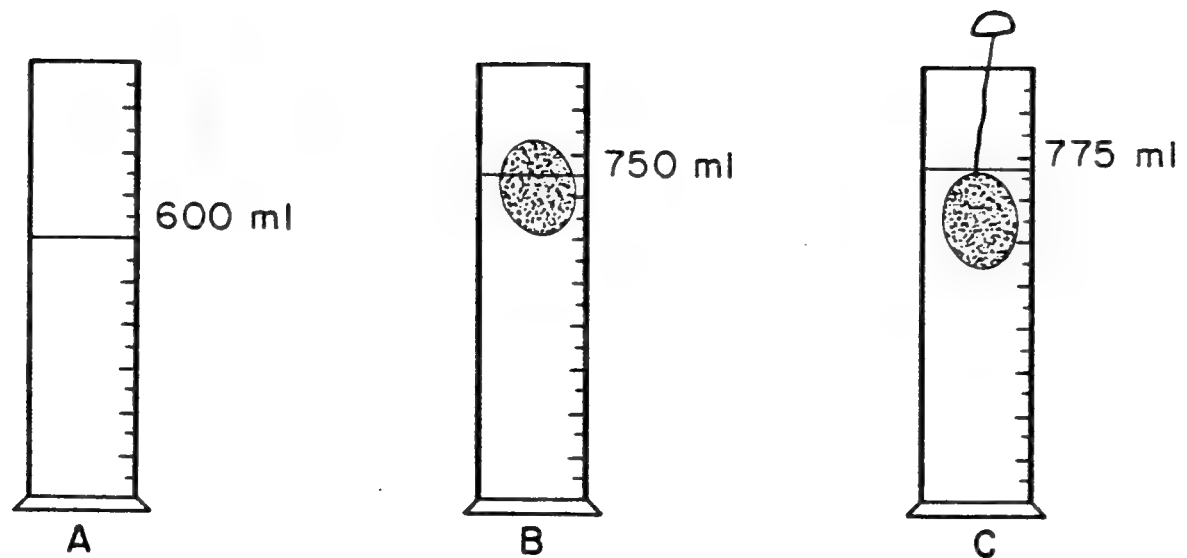
As cones and seeds of southern pines ripen, cone specific gravity (SG) decreases because of moisture loss. Since only mature cones can open and release seeds, collecting cones before maturity is useless unless they can be ripened artificially. Once the relation between cone ripeness and seed maturity is determined, cone specific gravity can be used to indicate when collection should begin. Customarily, collections are made during the 2- to 3-week period after specific gravity drops below 0.89, the normal index of maturity (Wakeley 1954). Since only limited labor is available for collecting cones, this period often is too brief to allow collection of seed orchard crops, and collection at higher specific gravities may be necessary. Recent studies have shown that the collection period can be almost doubled if some reduction in seed yields, and possibly viability, is acceptable (Barnett 1976).

Direct measurement of cone specific gravity requires weighing individual cones and weighing a container of water before and after cones are submerged. Specific gravity is computed by dividing cone weight by the weight of the water the cone displaces. Wakeley (1954) greatly simplified this time-consuming process by showing that flotation in light motor oil (SAE 20) indicated a specific gravity of 0.88 or less. Various mixtures of kerosene (SG 0.80), SAE 20 motor oil (SG 0.88), and linseed oil (SG 0.93) have been used to prepare flotation liquids with designated specific gravities. However, improvements in oil, such as the development of detergent oils, and the feasibility of lengthening the collection period by artificial ripening have resulted in a need for new ways to measure cone specific gravity.

An easy way to determine cone specific gravity is to use a graduated cylinder. The size of cylinder needed depends on the species of pine. A 1,000 ml cylinder probably is best for slash and loblolly cones. Smaller cylinders are better for species with smaller cones because graduations on these cylinders allow for more accurate readings. The procedure is fairly simple:

1. Fill the cylinder to a convenient level with water and note amount, i.e., 600 ml (Figure 1A)

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Cone weight:  $750 - 600 = 150$  grams  
 Cone volume:  $775 - 600 = 175$  grams  
 Specific gravity:  $\text{Weight} \div \text{volume} = 0.86$

Figure 1.--Determining cone specific gravity with a graduated cylinder.

2. Place a cone in the cylinder without splashing water out. If the cone sinks, specific gravity is greater than 1.0 and cannot be determined more accurately. The difference between the initial measurement and the measurement of the level with a floating cone gives cone weight. For example, if water level in the cylinder is now 750 ml, cone weight is 750 minus 600 or 150 grams (Figure 1B).
3. With a wire or small stick, submerge the cone and make another measurement of water level. The difference between measurements equals cone volume, i.e., 775 minus 600 equals 175 grams (Fig. 1C).
4. Compute specific gravity by dividing cone weight by cone volume:  
 $150\text{g} \div 175\text{g} = 0.86$ .

Several freshly picked cones from a number of trees should be checked before extensive collections are made because cone maturity can vary greatly among individual trees. However, this variance can be used to the advantage of the seed orchard manager. Relative specific gravity of different clones in the orchard can be determined in the early fall before cone maturity. Collections can begin with the clones that mature earliest and extend 2 to 3 weeks while others mature. The same collection sequence can be repeated each year.

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## CONE HARVEST OF EASTERN WHITE PINE .

Edwin H. Manchester<sup>1/</sup>

Abstract.--More harvest time is needed for white pine cones in seed orchards. Cones can be picked earlier by storing them on the ground and keeping them moist.

In the last ten years, the demand for white pine has soared and brought about an increased interest in reforestation and improved seed. Furniture made of white pine has become very popular with the new hard finishes to protect it. The market for balled and burlapped landscape trees is great, and quality white pine Christmas trees are at a premium.

This demand has created a need to harvest a lot of white pine cones in an ordinarily short picking season. In years when we weren't in this situation, we could wait until cones were a good yellow color and many floated in linseed oil as indicators of ripeness. This method only allows three to ten days to harvest the cones.

A paper written at Chittenden Nursery<sup>2/</sup> showed that white pine seed matured before cones began losing moisture. Average germination was up to 83% about two weeks before cone moisture began decreasing.

From the Michigan trials and our experience, we recommend white pine cone collection after the seed is out of the milky stage and cones are almost a straw yellow color. A small loss in seed germination may be expected if this is done, however, all the cones may not open when dried. This may be overcome to some extent by spreading them on the ground in a shady place and keeping them moist.

If we pick ripe cones, the acreage of genetically superior white pine in seed orchards should produce all the seed the Apalachian region can use.

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<sup>1/</sup> Seed Orchard Manager, USDA Forest Service, Murphy, NC.

<sup>2/</sup> Jones, LeRoy; Massello, James W. and Clifford, Edward D. 1967. Size and germination of white pine seed collected at weekly intervals from five trees. USDA Forest Serv. Res. Note SE-74, 6 pp. South. Forest. Exp. Stn., Asheville, NC.



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VACUUM SEED HARVESTING

James L. McConnell 1/  
James E. Gates 2/  
R. Merrell Graham 3/

Our experience with the Bowie Vac-U-Seed Harvester began in 1975 with the purchase of their latest model for \$17,500. The North Carolina State-Industry Tree Improvement Cooperative had conceived the idea of vacuuming seed from the orchard floor and had begun their work in 1968. We understand the coop built four prototype models in the seven years they tested the concept.

The Bowie Harvester is a self-propelled machine which uses a large vacuum head with an opening 3 inches wide by 60 inches long. A 240-cubic-inch, 6 cylinder Ford industrial engine drives a large paddle fan for suction and other power requirements of the machine. The front wheels are driven by hydraulic wheelmotors and the rear wheels are steerable. Two small caster wheels support the vacuum head and regulate its ground clearance. All material vacuumed off the orchard floor except fine dust is separated from the airstream by centrifugal action and falls through a rotating air lock onto a perforated sheet metal separator. The perforations allow seed and fine material to fall through, while the agitators "walk" the tailings (pine straw and other material) out the rear of the machine. The seed is moved forward by an auger and deposited into a screened hopper where it is stored until removed from the machine.

In the fall of 1975 Region 8 and the Missoula Equipment Development Center (MEDC) conducted tests with the machine on three loblolly orchards. The objective of these tests were to observe how the Vac-U-Seed Harvester performed under typical orchard conditions. We wanted to know how well the machine picked up seed from the orchard floor, what collection rates could be expected and the condition of the orchard floor for optimum machine performance.

Details of the 1975 tests were reported by Edwards (1976). In general, we found that the machine would pick up appreciable amounts of seed from the orchard floor if the floor were smooth, the grass mowed close and raked, and the grass was relatively dry. It was difficult to tell how much seed was being picked up by the machine. On a non-statistical basis we felt that about 80 to 90% of the seed on a well prepared (mowed and raked) orchard floor was being recovered by the vacuum harvester. Efficiency in separating seed from debris was directly affected by dampness of the material.

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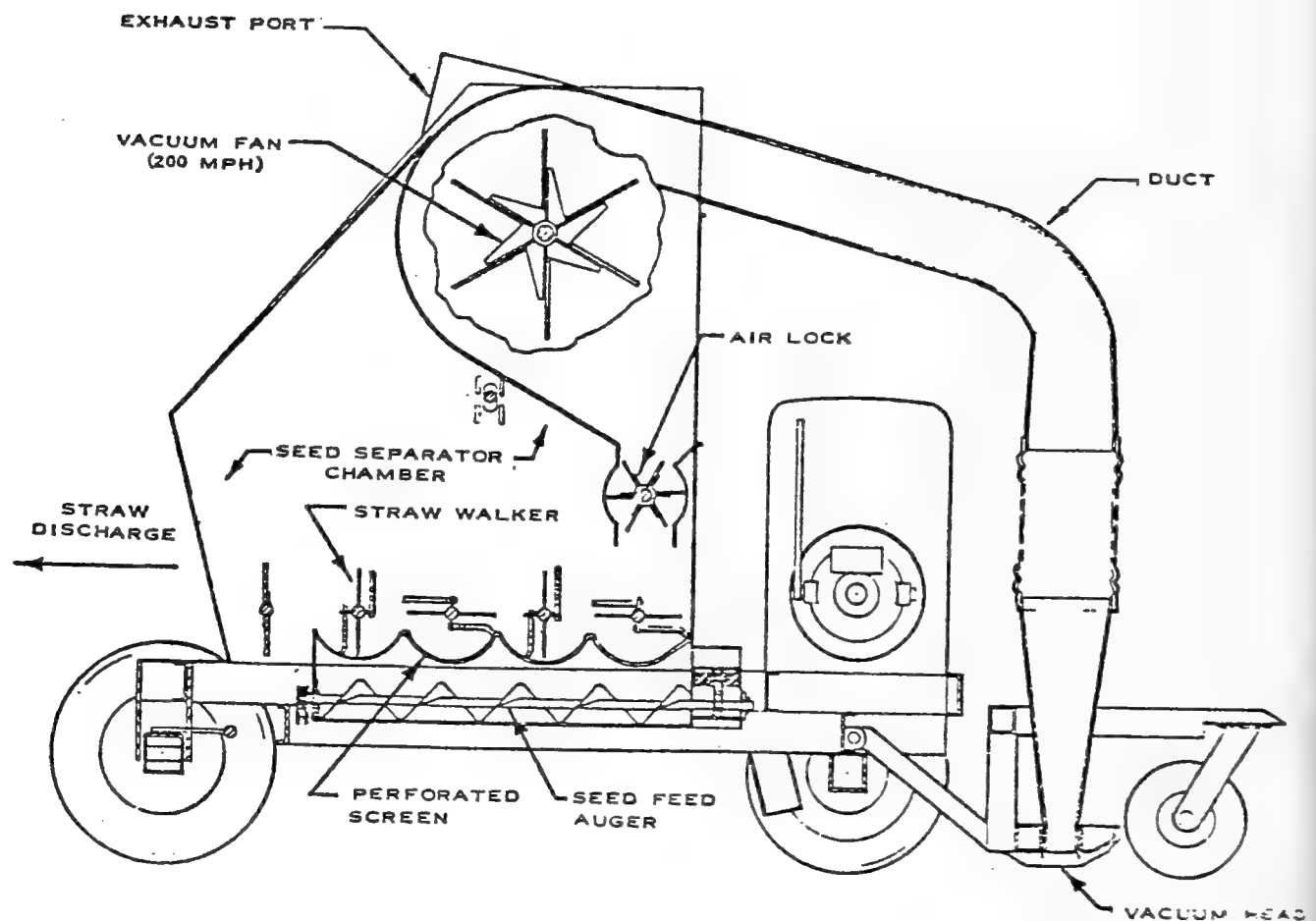
1/ Regional Geneticist  
U.S.D.A. Forest Service  
Atlanta, Georgia

2/ Western Zone Geneticist  
U.S.D.A. Forest Service  
Alexandria, Louisiana

3/ Seed Orchard  
Manager  
U.S.D.A. Forest  
Service  
Brooklyn, MS

With dry conditions, an estimated 95 percent of the seed picked up was recovered in the hopper. The seed coming out of the machine's seed hopper was not completely clean. This did not present a problem. It was not intended that the vacuum machine be the ultimate in seed cleaning. Picking the seed off the orchard floor and making a rough separation of the pine needles and grass from the seed was all we expected. Further, cleaning of the seed lots could best be done on more sophisticated equipment at a conventional seed cleaning plant.

The harvester had many mechanical and hydraulic malfunctions that caused downtime and reduced productivity. The problems encountered ranged from two days lost time when a hydraulic pump had to be replaced to the tightening of sprocket set screws at least once a day resulting in delays up to half an hour each time.



**Right Side ( Section )**

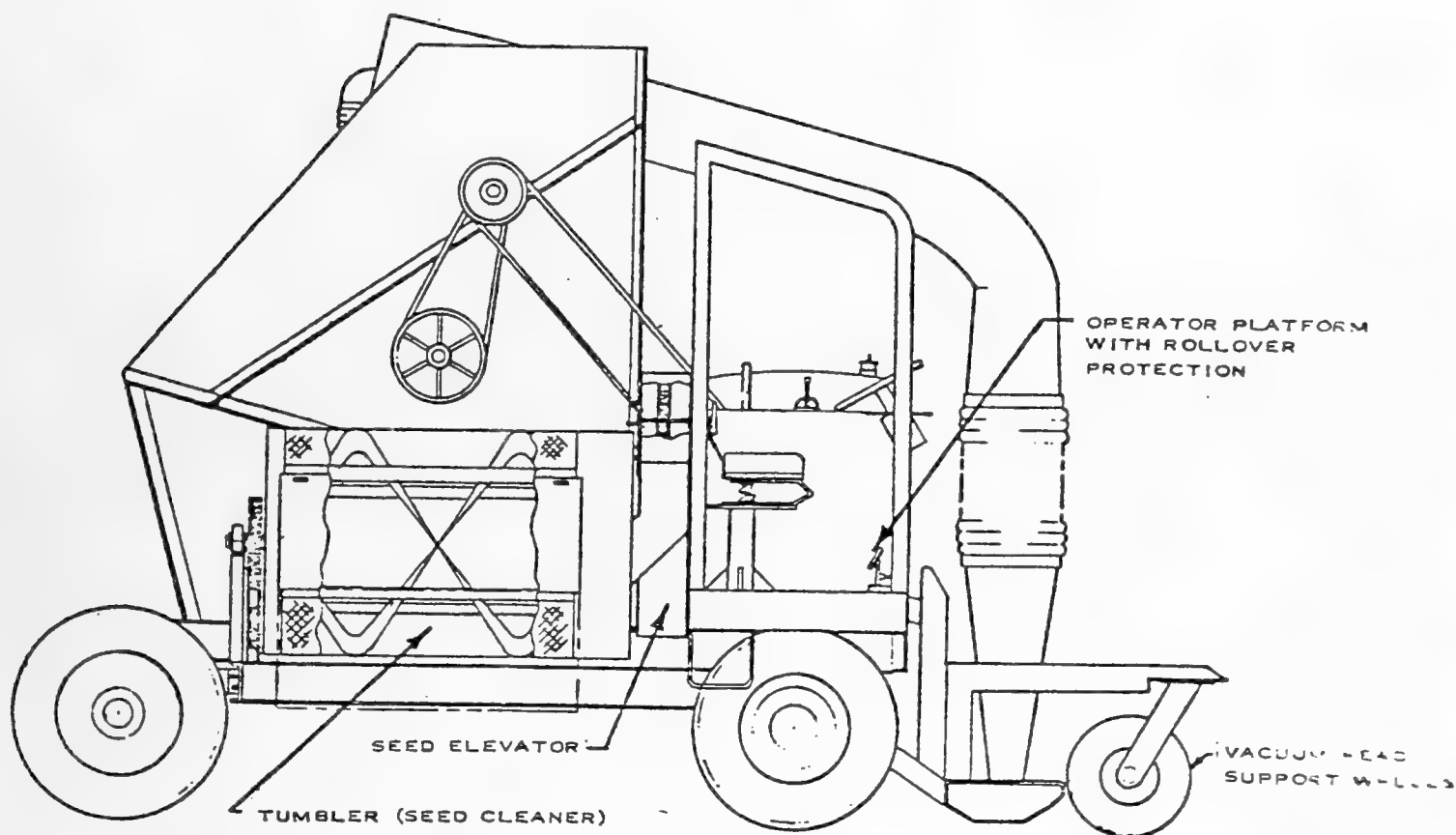
One continuing source of trouble was the discharge of pine straw and other debris from the machine. This material built up quickly at the discharge end of the straw walker and if not detected almost immediately would back up as far as the air lock. Small-scale blockages occurred regularly.

but only took a few minutes to correct. One major blockage took two hours to clear. The straw walker became overloaded several times during testing. The torque capacity of the shafts, combined with the tightly lodged pine straw and other debris, bent and broke the steel fingers as they rotated.

The harvester's maximum production rate during testing was two acres an hour. The machine's sustained production capability was not established because of the mechanical problems experienced.

Following the first year's testing a number of modifications were made by Bowie and several engineering and design items were improved. The major modification was to enlarge the separator to allow the machine to handle greater volumes of material and provide easier access to the interior for servicing the harvester.

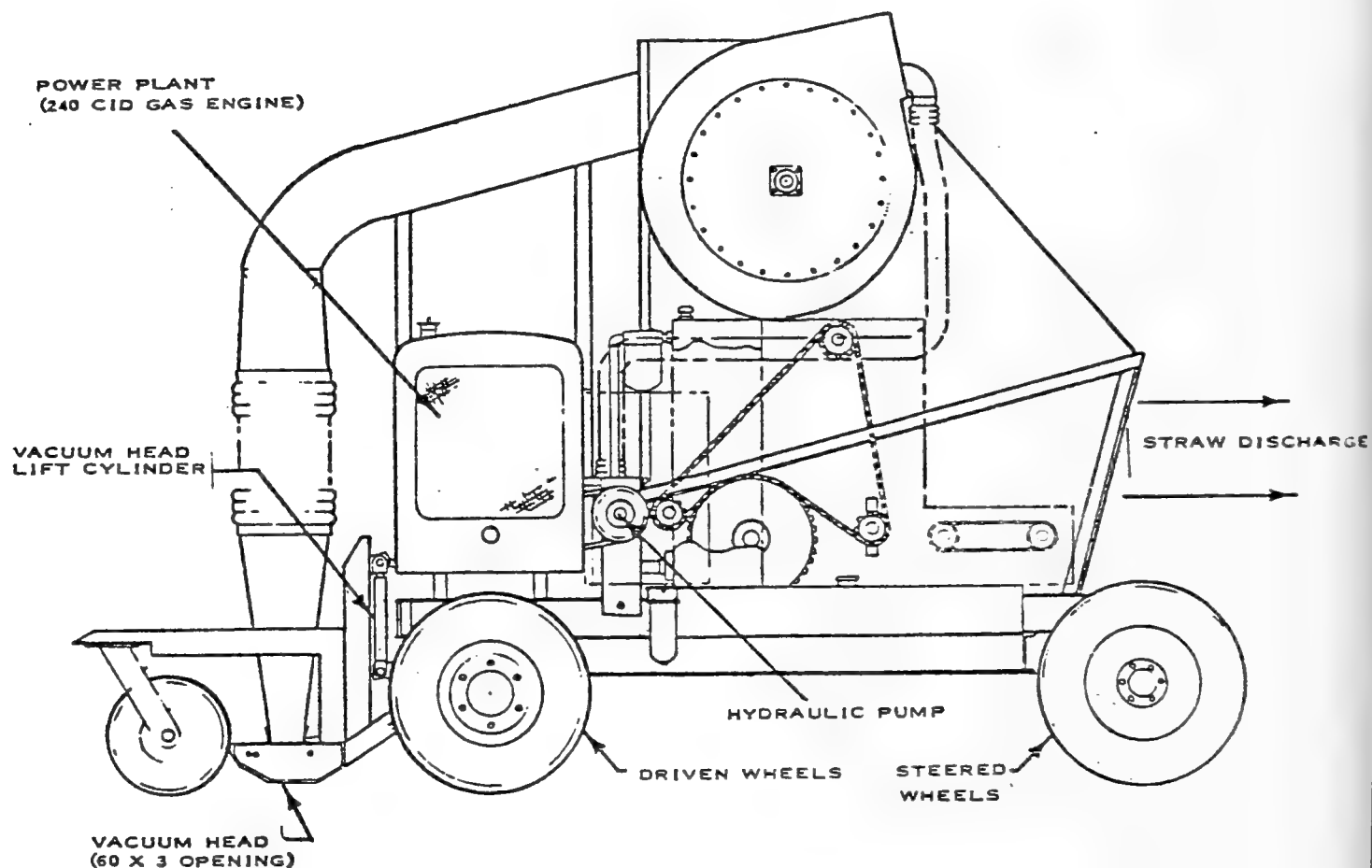
We decided to further test the machine the following year at Erambert Seed Orchard in Mississippi. A combination of a very poor cone crop and



**Right Side**

frequent rains during the test period made the 1976 tests rather inconclusive. It rained a total of 15.64 inches during 26 days of the 70 day test period (November 7, 1976 to January 15, 1977). The frequent rains certainly limited the effective operating time and efficiency.

Determination of percent seed recovered was estimated by installing a series of 12" x 12" plots and counting the number of seed on the plot before and after using the harvester. This method was very time consuming and not too accurate. It was impossible to insure 100% inventory of seed on each plot. Using the plot method, percent seed recovered on November 10, 1976 averaged 72.9 with a sampling error of  $\pm 10\%$  at 90% probability. The range between plots was from 31 to 91% recovery. Following the harvester operation on December 9, sufficient plots were taken to reduce the error to  $\pm 10\%$  at 95% probably. The range of seed recovered, this date, was 66 to 93% with an average of 80. These results were obtained with a single pass of the seed harvester.



**Left Side**

Due to the low seed production and frequent rains, a meaningful comparison of different treatments to the orchard turf was not completed. It was apparent that a heavy build up of grass clippings tend to clog the harvester more frequently and necessitated emptying the seed tumbler more often. A thick mat of dead grass takes much longer to dry reducing the time available for operating the harvester.

Tests conducted at the Eastern Tree Seed Laboratory indicated lower germination of seed recovered by the harvester than of seed extracted from cones by hand. Full seed germination of three check lots averaged 99% while eight samples taken from the harvester averaged 85%. The ETSL did not report any seed damage evidenced by x-ray.

Time and length of seed fall are factors that influence the success of any type of seed harvesting system. As the cones opened in the orchard, the ramets were shaken with a tree shaker to hasten seed fall and thus shorten the collection period. We also hoped more seed could be removed from the cones and thus increase the yield of seed per acre. A study to determine the effectiveness of the tree shaker or percent seed remaining in the cones was conducted during the Vac-U-Seed-Harvester evaluation. Prior to cone opening three cone clusters on each of two ramets of five clones were caged (total 30 cages). The cages were placed in the lower, middle, and upper portions of the crown of each tree.

Seed in each cage were counted following use of the tree shaker on November 9 and on December 9. The caged cones in the middle portion of each tree were removed after the first shaking and the number of seed remaining in the cones determined. The 32 cones examined had an average of 44 seed remaining or approximately 59 percent of their total. None of the cones were collected after the December shaking. Any additional seed that had fallen without further use of the tree shaker were counted on January 12, 1977. All remaining cones in the study were collected and seed extracted by hand.

The following table summarizes the results:

<u>Date</u>	<u>No. Cones included</u>	<u>Average Seed per cone recovered</u>	<u>Percent of Total seed recovered</u>
November 9	91	31	43
December 9	59	9	55
Jan. 12 (in cage)	59	9	67
Jan. 12 (in cones)	59	24	100
		<u>73</u>	

As a result of the modifications made following 1975 testing, the air lock, straw walker, and auger were capable of handling much greater volumes of material. Very little build up or bridging of pinestraw and debris in these components occurred during the 1976 tests. Two new problems apparently resulted from enlarging the separator. Because of the increased volume of material being picked up and processed, jamming did occur in the chute fed by the elevator bringing material from the auger. The second problem developed because of the increased width of the straw walker-separator. The debris from the machine, which is dropped on the ground behind the harvester, is partially in the way of the vacuum head during the succeeding pass. Reprocessing a portion of this material reduces the machine's capacity with unprocessed material.

A few other minor mechanical problems were noted during the limited time of harvester operation. A real good test of the harvester's mechanical reliability was not possible because of the unusual amount of rain. There were measurable amounts of rain on 40 percent of the days during the test so it was just too wet to operate the harvester.

The principal modification resulting from the 1976 testing was to rebuild the chute carrying material from the elevator to the seed tumbler or hopper.

Again in the fall of 1977 the Bowie Vac-U-Seed Harvester was operated and evaluated at the Erambert Seed Orchard in Mississippi. Although cone production was greater than in 1976, the crop was poor to light on the area selected for harvester use.

What was felt to be a minor change following 1976 operation resulted in a major problem during 1977 period of testing. Both the rigid and flexible fingers on the shafts in the straw walker were changed to rubber base steel tipped teeth and flexible rubber chicken plucking fingers. As a result, the straw was not given enough bouncing action to "walk" to the end of the machine. The straw had a tendency to settle down or wrap around the shafts. The new teeth would break off allowing the buildup of straw to become even greater until the machine would jam or belts break. This was the biggest mechanical problem encountered during 1977 testing.

Six acres of loblolly orchard was prepared for seed collection by the vacuum harvester. Between July and November the grass was cut 14 times. This was 11 mowings more than the normal orchard practice. A commercially made greens sweeper was used on the area three times in late October and early November to remove grass clippings and pine straw. The Bahia Grass Turf was in excellent condition. The additional cost for this degree of turf management was \$155 per acre.

The vacuum harvester operated a total of eight hours on November 14 and December 7. Two passes over the six acres recovered 17 pounds of seed. Approximately the same amount was collected each time. This averaged 1.5 acres per hour of harvester operation.

In an attempt to evaluate the vacuum harvester effectiveness seed yield from an adjacent area of orchard was determined by collecting the cones by hand. The area was 1.9 acres in size and contained 34% as many trees of cone bearing size, than did the six acres collected with the vacuum harvester. Seed yield was 15 pounds from the 23 bushels of cones collected. It cost \$17.50 per bushel for labor to collect these cones.

The following is a comparison of the two areas:

	AREA	
	<u>Hand Picked Cones</u>	<u>Vacuum Harvester</u>
Pounds of seed recovered	15	17
Estimated seed production (LBS.)	15.75	43.7
Estimated % seed recovered	95+	39
Additional Turf Management costs/acre	-	\$ 155
Seed collection cost/lb.	\$ 26.83	\$ 6.88
Seed collection cost/acre	\$211.84	\$ 19.50
Total Cost per acre (Turf Management and collection)	\$211.84	\$ 174.50

The above cost figures must be viewed in the proper perspective.

They deal only with seed recovered. Consideration must be given to the high value of genetically improved seed that was lost in the vacuum harvester operation. The costs for cone collection may have been higher, but close to 100% of the seed was collected as compared to about 40% for the vacuum harvester.

Also, cost per pound of seed or per acre will vary much more from year to year with the cone collection system than with the vacuum harvester. In a good seed year the yield is likely to be 1.5 pounds per bushel and collection costs could drop to less than \$7 per pound of seed. Due to the increased number of bushels the cost per acre would be greater even though collection costs per bushel is lower. On the other hand, costs of operating the harvester are fairly independent of production. In a good year (seed and weather) costs could easily be less than \$3 per pound.

Since the vacuum seed harvester seems to be economically feasible, the question of machine efficiency must be asked. Using the area comparison this year, we estimate 39% of the seed yield was recovered by the vacuum harvester. From last year's observations of individual plots, seed recovery by the vacuum harvester is probably in the 70 to 80% range. No additional study was made this year to determine number of seed remaining on a plot.

It was estimated about 30% of the seed remained in the cones after shaking the trees on December 7. This will certainly vary depending upon the weather. Although loss from birds and rodents was not measured, we feel it could run as high as 10% of the seed. With these assumptions, the distribution of the seed crop was as follows:

Seed recovered by the vacuum harvester	39%
Seed remaining in cones left on trees	25-30%
Seed left on ground	20-30%
Seed loss to birds and rodents	10%



After working with the vacuum seed harvester for several years, we must conclude it could be a workable tool in the collection of seed orchard seed. The vacuum harvester will pick up seed from a properly prepared orchard floor. The biggest problem with the machine is the process of separating the seed from grass, pine straw and other debris. Machine modifications have greatly reduced the amount of downtime due to stopages in the air lock, straw walker, or in the seed feed auger. Even with these modifications the harvester is not capable of satisfactorily handling large volumes of material.

The problem of separating seed from other debris is not to say the seed lots should come out of the machine ready for storage. The abrasive action of the system generally dewings most loblolly seed. Too, trying to hang a seed cleaning plant on a small machine is not practical. The seed should come out of the machine in a condition that can be easily solved on most permanent seed cleaning machinery. The moisture content will have to be lowered before storage.

Before an orchard manager can consider using a vacuum seed harvesting machine he will have to get his seed orchard floor and turf in tip top condition. The orchard floor will have to be smooth, without holes and ruts. The turf will have to be thick and cut close. Seed has a tendency to sift down through the grass to the ground. It is then hard to vacuum up. If the turf is thick, it will hold the seed in a position to be picked up.

Dead grass, pine needs, and thatch must be picked up or raked out of the way. All of this material will tend to clog and slow the machine.

We plan to continue using the machine in a portion of the orchard where the turf and orchard floor is in excellent condition. It is a seed source in which we have plenty of seed. We can concentrate our cone collection effort on other sources in the orchard and come back later to vacuum collect this area.

Until the separation problem can be solved, the Bowie Vac-U-Seed Harvester will not be a first line seed collection system. We hope the principal of separating the seed from grass, pine needles and trash can be solved on the net-retrieval system. Perhaps, then, it can be incorporated in the vacuum harvester machine.

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SEED TESTING AND SEED COLLECTION [ ]

by

R.P. | Karrfalt <sup>1/</sup>

Abstract. --An introduction to the need and ways of evaluating seed at harvest is given. The procedure is also described for evaluating the effect of collection systems on seed quality.

Keywords: Seed quality, crop evaluation, tetrazolium, excised embryo, X-ray, collection procedures.

Major failures and delays in seed production can be avoided and seed production can generally be improved by the proper use of seed testing. The major applications of seed testing to seed collection are: (1) immediately before and after the harvest, and (2) in the evaluation of collection procedures.

#### APPLICATIONS

##### Seed crop evaluation

Harvesting seed is more cost effective when done in areas where cones and fruits contain the most potentially sound seed. A quick and reasonably accurate method of measuring viability is therefore very useful. The procedure of making one longitudinal cut through a cone to evaluate the number of filled seeds has long been practice. Sometimes this procedure worked, sometimes not. Errors in sampling could likely be reduced if green cones were dissected, or opened in a microwave oven, so that all seed were available for quick evaluation by x-ray rather than looking at only those seed lying along the single plain of the cut.

X-ray evaluation is of value with hardwoods also. Species such as ash, sweetgum, sycamore and yellow poplar often produce very few filled seed. Evaluation of many seed of these species by a cutting test would be very time consuming. An x-ray test, however, can give a fast accurate evaluation of a relatively large sample of seed.

A rapid estimate of viability following harvest is also important. The harvest season might end before an accurate germination test can be completed. However, a quick test can give an evaluation while there is still time to collect additional seed if necessary.

1/ Assistant Director, Eastern Tree Seed Laboratory, Macon, Ga. The Laboratory is operated cooperatively by the Georgia Forestry Commission and the USDA Forest Service, Southeastern Area, State and Private Forestry.

### How to evaluate rapidly

Tetrazolium.-- The tetrazolium, or TZ, test involves cutting open the seed, applying a solution of the chemical tetrazolium, and making a microscopic evaluation of the staining and firmness of the seed tissue.

Excised embryo.-- Excised embryo testing involves removal of the embryo from the seed, under semisterile conditions, so that it can be germinated free from the inhibiting environment of the seed coat and food tissue.

X-ray.-- The ease and speed of application of x-ray testing make it very well suited to a seed collection operation. Generally, no preparation of the seed is required and results are available in less than one hour, where tetrazolium requires 24 to 48 hours and an excised embryo test, 7 to 14 days.

### Evaluating collection procedures

Seed orchards and new technology have created a new environment for seed collection. New methods of seed collection have evolved, such as the net collection system and the vacuum seed harvester. New systems require careful evaluation to determine their effects on seed quality.

Procedures are evaluated by drawing samples of seed by hand before and after each step in the collection process. These samples can be carefully cleaned in the office or laboratory and then tested with x-ray and germination. Any significant decrease in quality between samples indicates that the intervening step injures the seed. This step would then need to be modified or eliminated.

214 [ 3 ]  
PREDICTING LOBLOLLY SEED ORCHARD CONE CROPS  
BY MEANS OF SUMMER BINOCULAR COUNTS

Ronald G. Wasser and Thomas A. Dierauf<sup>1/</sup>

Abstract.--In order to predict fall cone crops in the Virginia Division of Forestry loblolly seed orchards, various counting methods were attempted in mid-summer. Of these methods, binocular cone counts made from the ground on a small percentage of the total trees in the orchard provided a reasonable estimate of the size of the crop to be harvested in the fall.

We have 350 acres of loblolly pine seed orchard at two locations in Virginia. The ages of the blocks in these orchards range from 18 years down to young blocks just beginning to bear cones. The combination of large acreage and considerable variation in tree age and size makes it difficult to estimate how large a cone crop we will have to collect each fall. In the summer of 1975 we installed a study to compare two general approaches to estimating the size of our cone crop. One involved an accurate count of the number of cones on the upper whorls of sample trees using a bucket truck. The other involved a quicker and easier counting from a point on the ground of all cones visible through binoculars. Binocular counts were made from the ground, at a distance of 66 feet from the tree, from a single point in the south quadrant (SE to SW). We expected that in a given amount of sampling time we would be able to sample more trees using binoculars than counting from a bucket truck, but we thought at the time the more accurate counts from the bucket truck might provide a better estimate for a given amount of time spent sampling.

#### 1975 STUDY

We sampled 36 trees in our two oldest seed orchard blocks and 21 trees in two of our youngest producing blocks. As expected, binocular counts were quicker, taking an average of two minutes per tree, while counts from the bucket truck required four and twelve minutes per tree for counting the cones on the top four and eight whorls respectively. Total cone counts were made from the bucket truck at the same time the sampling was done. Simple linear regressions were used to relate the total counts to the sample counts. The binocular counts were not only faster, but also provided a better estimate of the total number of cones per tree (table 1).

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<sup>1/</sup> Superintendent, Tree Improvement and Chief Applied Forest Research, Virginia Division of Forestry

Table 1.--Sampling time and amount of variation (in total-tree cone counts) explained by the three sampling methods.

Method	Sample Time Per Tree	$r^2$	
		Older Blocks	Younger Blocks
Binoculars	2 minutes	.788	.727
Top 8 whorls	12 minutes	.728	.711
Top 4 whorls	4 minutes	.227	.316

#### SUBSEQUENT STUDIES

In 1976, 1977 and 1978 we made similar studies, relating the total number of sound cones when the cones were harvested in the fall to the number of sound cones that could be seen with binoculars in July. In each of the three years, trees were sampled in four coastal plain and four piedmont blocks, ranging from our oldest to youngest cone-producing blocks. Sample trees in each block were selected systematically so that the sample would be representative of the block.

The individual sample tree data for each block were plotted on graph paper. Total cone counts were related to binocular counts by simple linear regression, and these regression lines were also plotted. We decided that the ratio-of-means regression estimator (Frank Freese, 1962. (Elementary Forest Sampling, Agriculture Handbook No. 232, page 36) would be more appropriate than the simple linear regression estimator because:

- (1) In all cases, variation about the regression line increased as the binocular counts increased.
- (2) Most of the regression lines intercepted the "y" axis at a point close to zero.

These two factors are illustrated by Figure 1, which shows the plotting of a typical set of data along with the simple linear regression line. The standard errors of estimate for the two regression estimators are almost identical in most cases (table 2).

The ratio-of-means estimator is simply:

$$\text{Ratio-of-means } (\hat{R}) = \frac{\text{Average Total Cone Count } (\bar{Y})}{\text{Average Binocular Count } (\bar{X})}$$

It is simple to use, requiring only that the average binocular count ( $\bar{X}$ ) for a seed orchard (or block) be multiplied by an appropriate ratio ( $\hat{R}$ ) determined by a previous sampling, and weighted by the number of trees in the orchard or block.

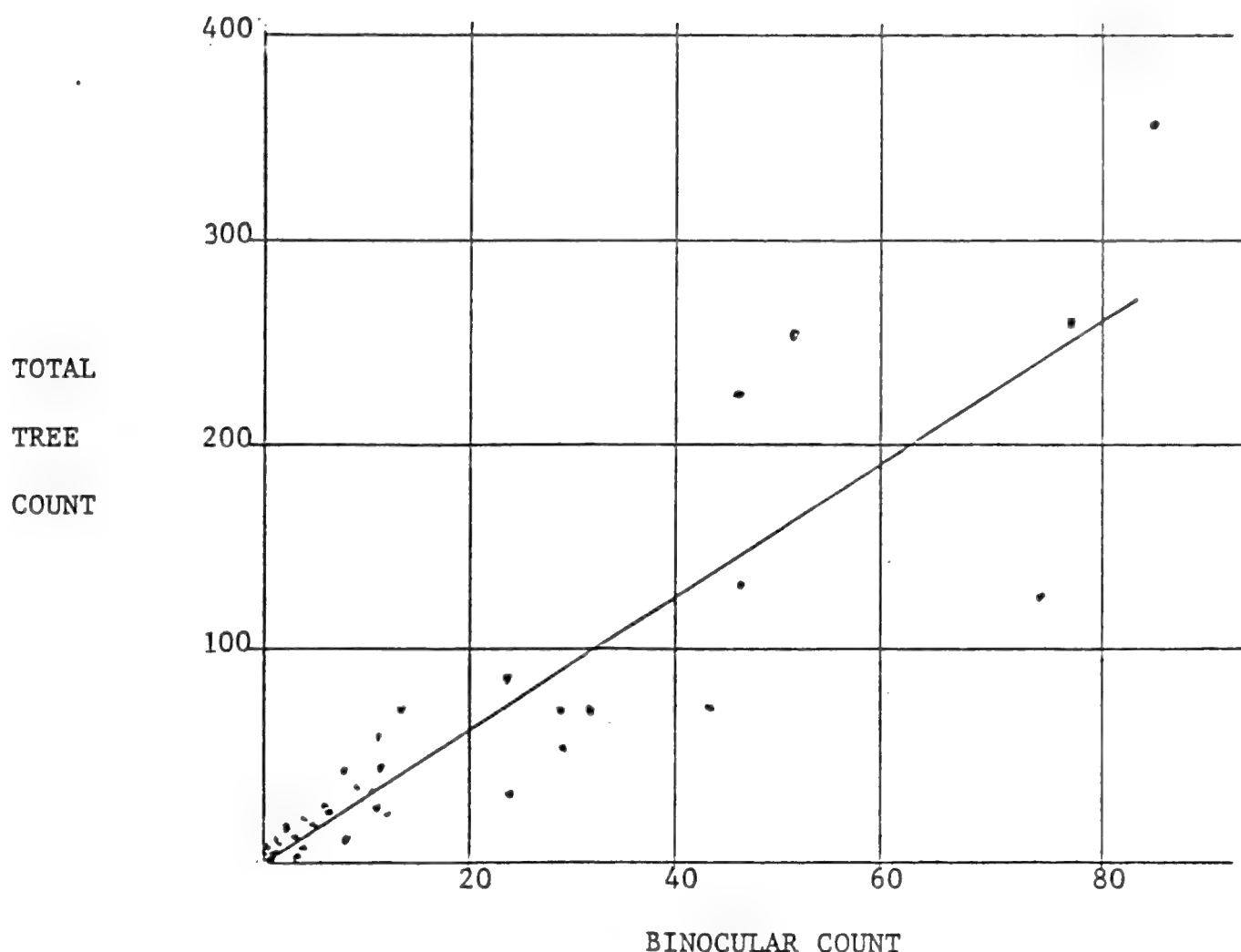


Figure 1. Plotting of total tree counts over binocular counts for Coastal Plain 1 East, 1978. In addition to the 36 trees plotted, there were 4 trees with zero counts.

For the three years, we have 24 different values of  $\hat{R}$  (three years sampling of eight orchard blocks). Average total number of cones per tree and average DBH varied considerably between years and blocks (table 3). The values of  $\hat{R}$  were plotted over average total cone count and average DBH to see if there was a tendency for  $\hat{R}$  to increase with number of cones and DBH, but this was not true in 1977 and 1978. It may be that orchard blocks of different tree size, age, and productivity can be combined in one sample.

To test this possibility, the data from all eight blocks were pooled to calculate an overall  $\hat{R}$  for each year. Finally, the three overall  $\hat{R}$ 's for each year were averaged to obtain an overall  $\hat{R}$  for all eight blocks over all three years. These three different ways of estimating  $\hat{R}$  (separate by block and year, pooled by year, and averaged over all three years) were used to estimate the number of bushels of cones in each block and for all eight blocks combined in each year. The estimates were remarkably similar (table 4).

Table 2. Sample Data: sample size (n), average total (Y) and binocular (X) counts, ranges, simple linear regressions, ratio-of-means, standard error of estimate (SE), and coefficient of variation (CV)--by years and blocks.

Year & Block	n	Total Counts		Binocular Counts		Simple Linear Regression			Ratio-of-Means		
		Mean Y	Range	Mean X	Range	a	b	SE	R	SE	CV
1976											
CP-1W	40	125.8	0-516	38.5	0-212	23.7	2.65	9.4	3.27	10.4	8.3
1E	75	50.8	0-375	15.0	0-138	4.0	3.12	4.0	3.39	4.1	8.0
2	67	16.8	0-156	6.3	0-51	-.3	2.69	1.7	2.65	1.7	9.9
5	91	4.5	0-64	2.7	0-33	.2	1.58	.3	1.67	.3	7.3
P-1	71	69.8	0-653	21.8	0-195	.4	3.18	4.4	3.20	4.4	6.3
2	127	24.7	0-300	10.2	0-123	.7	2.36	1.2	2.43	1.2	5.0
3	91	13.4	0-238	5.9	0-88	-1.1	2.46	.8	2.27	.8	6.1
4	77	16.7	0-158	7.7	0-75	.2	2.14	1.3	2.16	1.3	7.8
1977											
CP-1W	22	95.4	0-217	43.4	0-168	17.6	1.79	13.2	2.20	13.6	14.3
1E	38	22.1	0-134	8.9	0-59	3.2	2.11	3.3	2.47	3.4	15.3
2	39	2.9	0-32	1.5	0-10	-.2	2.13	.5	2.00	.5	15.7
*5	40	.2	0-3	.0	0-1	.2	.82	.1	8.00	.2	105.0
P-1	38	67.1	0-407	23.8	0-119	1.1	2.77	4.6	2.82	4.5	6.7
2	38	22.1	0-489	6.7	0-122	-2.4	3.66	2.2	3.30	2.6	11.7
**3	36	.2	0-9	.2	0-7	.0	1.29	.2	1.29	.0	.5
4	35	10.2	0-257	2.0	0-54	.6	4.86	1.0	5.16	1.1	10.4
1978											
CP-1W	42	217.5	0-1298	48.9	0-261	4.5	4.36	20.0	4.45	20.8	9.6
1E	40	60.1	0-345	18.6	0-84	.5	3.21	5.3	3.24	5.2	8.7
2	41	56.0	0-241	17.7	0-94	13.8	2.38	4.9	3.16	5.7	10.1
5	40	11.1	0-85	3.2	0-23	2.1	2.84	1.5	3.50	1.6	14.1
P-1	38	135.6	0-473	43.4	0-139	-0.6	3.14	6.7	3.13	6.6	4.9
2	40	87.0	0-729	24.8	0-167	-4.4	3.69	8.0	3.51	8.0	9.2
3	39	15.2	0-115	6.6	0-36	-1.3	2.49	1.5	2.29	1.5	10.1
4	42	18.8	0-280	6.7	0-138	3.3	2.30	3.3	2.79	3.7	19.7

\* Only 4 of the 40 trees sampled had any cones on them.

\*\* Only 1 of the 36 trees sampled had any cones on it.

Table 3. Average total-tree counts, average DBH, and ratio-of-means estimators ( $\hat{R}$ ) by year and block.

<u>Year</u>	<u>Block</u>	<u>Mean Total Count (Y)</u>	<u>Mean DBH</u>	<u><math>\hat{R}</math></u>
1976	CP-1W	126	12.0	3.27
	1E	51	9.3	3.39
	2	17	7.9	2.65
	5	5	5.1	1.67
	P-1	70	10.4	3.20
	2	25	8.1	2.43
	3	13	6.6	2.27
	4	17	8.1	2.16
1977	CP-1W	95	13.0	2.20
	1E	22	10.4	2.47
	2	3	8.8	2.00
	5	.2	5.8	8.00
	P-1	67	11.7	2.82
	2	22	8.9	3.30
	3	.2	7.2	1.29
	4	10	9.0	5.16
1978	CP-1W	217	13.8	4.45
	1E	60	11.0	3.24
	2	56	9.7	3.16
	5	11	6.5	3.50
	P-1	136	12.2	3.13
	2	87	9.8	3.51
	3	15	7.8	2.29
	4	19	9.6	2.79

Table 4. Estimates of bushels of cones using individual, pooled by year, and three year average values of  $\bar{R}$ .

<u>Year</u>	<u>Block</u>	<u>Total No. Trees</u>	<u>Individual</u>		<u>Pooled by Year</u>		<u>3 Year Average</u>	
			<u><math>\bar{R}</math></u>	<u>Bushels<sup>1/</sup></u>	<u><math>\bar{R}</math></u>	<u>Bushels<sup>1/</sup></u>	<u><math>\bar{R}</math></u>	<u>Bushels<sup>1/</sup></u>
1976	CP-1W	260	3.27	112	2.87	98	3.02	103
	1E	709	3.39	123	2.87	104	3.02	110
	2	652	2.65	37	2.87	41	3.02	43
	5	1616	1.67	25	2.87	43	3.02	45
	P-1	663	3.20	175	2.87	157	3.02	165
	2	1255	2.43	117	2.87	138	3.02	145
	3	894	2.27	45	2.87	57	3.02	60
	4	753	2.16	<u>47</u>	2.87	<u>63</u>	3.02	<u>66</u>
	Totals			681		701		737
1977	CP-1W	260	2.20	85	2.64	101	3.02	116
	1E	709	2.47	53	2.64	57	3.02	65
	2	652	2.00	6	2.64	9	3.02	10
	5	1616	8.00	1	2.64	0	3.02	0
	P-1	663	2.82	168	2.64	157	3.02	180
	2	1255	3.30	105	2.64	84	3.02	96
	3	894	1.29	1	2.64	2	3.02	2
	4	753	5.16	<u>29</u>	2.64	<u>15</u>	3.02	<u>17</u>
	Totals			448		425		486
1978	CP-1W	259	4.45	192	3.56	154	3.02	131
	1E	575	3.24	118	3.56	130	3.02	110
	2	652	3.16	125	3.56	140	3.02	119
	5	1601	3.50	61	3.56	62	3.02	52
	P-1	662	3.13	339	3.56	385	3.02	327
	2	1255	3.51	412	3.56	300	3.02	355
	3	880	2.29	50	3.56	56	3.02	67
	4	753	2.79	<u>53</u>	3.56	<u>49</u>	3.02	<u>58</u>
	Totals			1350		1276		1219

<sup>1/</sup> Total number of cones converted to bushels by dividing by 293 and 265 for Coastal Plain and Piedmont respectively.



### How Good Are the Estimates

We have separate cone collection records for the following blocks:

CP - 1W & 1E combined  
CP - 2  
P - 1  
P - 2  
P - 3

We compared the actual cone harvest from these blocks with the estimates for these blocks using the same three ways of estimating  $\hat{R}$ :

- (1) individual  $\hat{R}$ 's for each block and year
- (2) pooled  $\hat{R}$ 's for each year
- (3) the overall average  $\hat{R}$  for all three years

All three estimates of  $\hat{R}$  provided reasonably good predictions of the actual cone crop (table 5).

### CONCLUSIONS

It would seem that in our Providence Forge seed orchards, containing our clones an  $\hat{R}$  of 3.00 applied to an adequate sample of binocular counts should provide satisfactory estimates of the size of the cone crop. In 1977 and 1978 we made binocular counts of 4.2 and 4.9 percent of the trees in the eight blocks we sampled. The estimates obtained were good enough for what we wanted - a reasonable estimate in mid-summer of the size of the cone crop to be harvested in the fall. This  $\hat{R}$  value could vary considerably at other orchard locations, with other clones, with each individual, and under different growing conditions. Each orchard manager should compile this data for himself to make reliable predictions.

Table 5. Comparison of actual cone harvest with estimated cone harvest.

<u>Year</u>	<u>Block</u>	<u>Actual</u>	<u>Type of <math>\hat{R}</math></u>		
			<u>Separate by Block</u>	<u>Pooled by Year</u>	<u>3-Year Average</u>
1976	CP-1W & 1E	220	235	202	213
	2	61	37	41	43
	P-1	138	175	157	165
	2	96	117	138	145
	3	40	45	57	60
	Totals	<u>555</u>	<u>609</u>	<u>595</u>	<u>626</u>
1977	CP-1W & 1E	239	138	158	181
	2	14	6	9	10
	P-1	174	168	157	180
	2	69	105	84	96
	3	12	1	2	2
	Totals	<u>508</u>	<u>418</u>	<u>410</u>	<u>469</u>
1978	CP-1W & 1E	340	310	284	241
	2	67	125	140	119
	P-1	300	339	385	327
	2	226	412	300	355
	3	41	50	56	67
	Totals	<u>974</u>	<u>1,236</u>	<u>1,165</u>	<u>1,109</u>

214  
[ 3  
PLANNING THE HARVEST OF CERTIFIED  
SEED LOTS . "

by

E. W. Belcher 1/

### INTRODUCTION

Seed certification doesn't just happen; it must be planned and then carried out in the proper sequence. But first, let's recap the seed certification program.

Each state has a seed certification agency. It may be called the Crop Improvement Association, the State Plant Board or the Department of Agriculture. One thing it is not, is a forestry oriented agency. It is staffed by agronomists and, therefore, we must be understanding and educate them in forestry. Forests seed certification standards have been prepared and adopted in most of the Southern States. I stand prepared to assist both you and the State certifying agency to bridge the gap between adopted standards and implementation. A list of the certifying agencies in the Southeastern Area is given at the end of this presentation.

### CERTIFICATION AVAILABLE

There are three categories of seed certification in forestry. These are:

Source identified (yellow tag) -- no genetic data. Provides location of collection by State and county.

1/ Director, Eastern Tree Seed Laboratory, Macon, Ga. The Laboratory is operated cooperatively by the Georgia Forestry Commission and the USDA Forest Service, Southeastern Area, State and Private Forestry.

Select (green tag) -- trees selected on visual appearance such as seed production areas -- no genetic data.

Certified (blue tag) -- genetically proven stock.

#### CERTIFICATION PROCEDURE

First, contact the certifying agency in your State and become a member. With the membership you will receive a copy of the State standards.

For source identified material ( not available in all States), no field inspection is usually necessary, but can be made. Notify the certifying agency in writing by July 1 before cone collection. Following collection, file a notarized affidavit with the certifying agency, specifying the location of the collection or buying station, the buyer, and the number of bushels collected, arranged by species. After processing the seed, submit a final affidavit of seed available for sale, and tags, request.

In the latter two categories, apply to the certifying agency in July 2 years before collection. The certifying agency will send an inspector to view the area and report any sanitation work needed before pollination. A second inspection must be made before pollination if any cleanup is required. Then apply in July, before collection of the certifiable seed cones. The inspector will estimate cone production and verify integrity and cleanliness of the processing plant. After processing, make a test and submit it to the certifying agency. If the results are acceptable, request the appropriate tags to be sealed on the containers. If the

seed is to be planted, another inspection is required for sowing and lifting. A request is then made to tag the bundles of seedlings.

If the seed are to be shipped overseas, and Organization for Economic Cooperation Development certification will also be required. This is available through your State certifying agency, but is restricted to the species presently included in the certification standards of that state.

#### CERTIFYING AGENCIES IN THE SOUTH

##### Alabama Crop Improvement Association, Inc.

S. Donahue Dr., Auburn University, Auburn, Ala. 36830  
Robert A. Burdett, Secretary. Tel/Phone: 205-821-7400

##### Arkansas State Plant Board

1 Natural Resources Dr., P.O. Box 1069, Little Rock, Ark. 72203  
John Baldwin, Head, Seed Certification Sect. Tel/Phone: 501-371-1021

##### Florida Department of Agriculture and Consumer Service, Certification Section

Mayo Building, Tallahassee, FL 32304. Vincent Giallo, Director.  
Tel/Phone: 904-488-3731. Robert F. Ridenour, Administrator, Seed Section:  
Tel/Phone: 904-488-7626.

##### Georgia Crop Improvement Association, Inc.

925 West Whitehall Rd., Athens, Ga. 30605; Harvey C. Lowery, Extension  
Agronomist -- Seed Certification. Tel/Phone: 404-548-6810.

##### Kentucky Seed Improve Association, Inc.

P.O. Box 12008, Lexington, Ky. 40511. John C. Haight, Manager;  
Tel/Phone: 606-257-3878. Dennis M. TeKrony, Secretary; Department of  
Agronomy, University of Kentucky, Lexington, Kentucky 40506. Tel/Phone:  
606-257-3878.

Louisiana Department of Agriculture, Office of Agricultural and Environmental Sciences

P.O. Box 44153, Capitol Station, Baton Rouge, La. 70804. Richard Carlton, State Entomologist. Tel/Phone: 504-389-6001. •

Mississippi Seed Improvement Association

P.O. Drawer MS, Mississippi State, Miss. 39762: Walker W. Guery, Executive Secretary. Tel/Phone; 601-323-3240.

Missouri Seed Improvement Association

P.O. Box 852, University South Farm, Columbia, Mo. 65201. Waynard E. Aslin, Executive Secretary-Treasurer. Tel/Phone: 314-449-0586.

North Carolina Crop Improvement Association, Inc.

Box 5155, State University Station, Raleigh, N.C. 27607.  
Foil W. McLaughlin, Director in Charge. Tel/Phone: 919-737-2851.

Oklahoma Crop Improvement Association, Agron, Dept.

369 Ag. Hall, Oklahoma State University, Stillwater, Okla. 74047  
Edward L. Granstaff, Secretary-Manager, Tel/Phone: 405-624-7117 or 624-7118

Department of Seed Certification

Room 265, P&AS Building; Clemson University, Clemson, S.C. 29631;  
John O. Black, Jr. , Head. Tel/Phone: 803-656-3004.

Tennessee Crop Improvement Association

5201 Marchant Drive, P.O. Box 11019, Nashville, Tenn. 37211. Raymond E. Cobble, Executive Secretary. Tel/Phone: 615-832-1823.

Texas Department of Agriculture

P.O. Drawer 12847, Capitol Station, Austin, Tx. 78711. Don Ator, Assistant Director. Tel/Phone: 512-475-2038.

Virginia Crop Improvement Association

10 Sandy Hall, VPI & SU Blacksburg, Va. 24061. M.S. Baker, Secretary-Treasurer. Tel/Phone: 703-951-6488. Robert L. Harrison, Extension Specialist; 420 Smyth Hall, VPI & SU, Blacksburg, Va. 24061. Tel/Phone: 703-951-5797.

The material I have presented here is not specific to any State. Because there are differences, I have presented a general overview. For specific interests contact your certifying association or the Eastern Tree Seed Laboratory.

245  
• COMPARISON OF TWO STORAGE METHODS FOR PINE CONES  
by H.H. Gresham 1/

During 1977 a cone processing plant was constructed at the St. Regis Nursery located near Lee, Florida. This plant uses a tumbler/dryer to heat and extract seed from the cones. It was built especially for our needs since an optimum charge is 80-100 bushels. The tumbler/dryer is basically a wire mesh covered barrel 20 feet long and 7.5 feet in diameter that is encased in a steel shell. It has a built-in LP gas burner air circulating system. When the cone scales begin opening, the tumbler/dryer is programmed so that the barrel rotates to a desired schedule. Usually it is at rest 25-30 minutes and then rotates 2-5 minutes. When the barrel rotates, the seed falls through the mesh to a conveyor belt below.

Seed cleaning is accomplished in four stages by individual machines. They are: (1) dry dewinger, (2) scalper, (3) wet dewinger and (4) cleaner/sizer. The scalper and cleaner/sizer represented the latest adaptations of agricultural grain cleaners for pine seed. The two dewingers are prototypes of machinery designed especially for pine seed.

It was decided to test two methods of cone storage for our plant. They were burlap bags containing one bushel each and 20 bushel wire bound crates. Our slash seed orchard near the nursery was chosen to supply the cones. There were 20 clones represented in this portion of the orchard. Since the number of ramets varied, it was decided to use two containers of one bushel capacity each and divide the cone collected from each tree between the two. This insured that an equal number of cones from each ramet would be represented in the two methods.

The actual collection began on September 12, 1977 and was completed the next day. All cones were stored under an open shed. The bags were placed on pallets since the crates had their own pallet.

Processing of the four 20 bushel crates began on December 8, 1977. These cones remained in the tumbler/dryer for 13 hours at 105°F. The seeds, wings, scales and other debris from this operation was then subjected to the dry dewinger, scalper, wet dewinger and cleaner/sizer respectively. The clean seed was then dried to a moisture content of 8%. A total of 83 pounds of seed was obtained from these four crates for an average of 1.04 lbs/bu.

On December 9, 1977, the cones from the 80 burlap bags were placed in the tumbler/dryer. They also remained in the tumbler/dryer for 13 hours at 105°F; however, after 6 or 7 hours essentially all seeds had been extracted from the cones. The same screen and air settings that were used for processing the seed lot from the 20 bushel crates were maintained when cleaning the pops and debris from the burlap bag seed lot. A total yield of 108 pounds or 1.35 lbs/bu of clean seed was obtained after dried to 8% moisture content.

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1/ St. Regis Paper Company Cantonment, Florida

It was decided to conduct the same trial again the following year. The 1978 cone crop at the Lee Orchard was much poorer than the 1977 crop. Collection began September 9, 1978 and was conducted in the same manner as in 1977 except that additional orchard acreage was needed to obtain 160 bushels.

Extraction and cleaning began on October 30, 1978 for the crates and October 31, 1978 for the cones in burlap bags. This was approximately five weeks less storage time than the previous year. The clean seed yield was extremely low for each lot. The total from the wire bound crates was 22 pounds or 0.28 lbs/bu and for the bags, 26 pounds or 0.33 lbs/bu.

There was a 30% increase in weight of clean seed for burlap bag storage over using the 20 bushel crates for the 1977 crop. An 18% increase was recorded for the burlap bag storage method for 1978. This was a reduction from the previous year, but the increase was still in favor of the bag storage. Also a high percentage of pops was present for both methods in 1978 which could have had some influence.

From these results, St. Regis has adopted the burlap bag method to store cones for processing at the Lee, Florida seed extractory. Also, until St. Regis has surplus seed orchard seed, any method within reasonable cost that increases seed yield will be received favorably.

A general statement that bag storage is superior to the crate storage is not advocated since the processing at Lee is somewhat different from most other facilities.



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POST HARVEST STORAGE OF  
CONES AND FRUIT C 3

by

E. W. Belcher <sup>1/</sup>

Back in the days when all collections were made from wild stands and lone trees, storage procedures were automatic. A large portion of the cones were collected by the public and delivered to buying stations. After grading, the cones were sacked in burlap bags and stacked in drying sheds. The large fans at the end of the sheds, if they existed, were turned on, or smaller fans were placed at the doors to create a draft. The sacks of cones remained that way until time permitted processing them. Occasionally, the storage sheds were filled and sacks were stacked two sacks deep on concrete parking lots and wherever space allowed. Hardwood fruits, on the other hand, were usually in small supply and were dumped onto screened trays and stacked in a sheltered area until time permitted working with them.

Since that time, tree improvement programs have developed to the point that many agencies are now collecting their regeneration needs from improved stock. This has shifted cone collection from the public sector to the professional forester and technicians. The concern of cone handling has now become one of collection and handling, with the emphasis on maximum collection in a minimum time.

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Burlap bags were replaced with wire bound pallet boxes (Isaac, 1976). Some have found these favorable, while others have found them detrimental, as already discussed at this session.

It is my opinion that too much pressure to produce often leads to excessive simplification, which throws caution to the wind. It is extremely important that we all recognize that there are exceptions, and that basic concepts have limitations when used too broadly because of these exceptions.

It was well known in the 1950's that you do not pile pine cones because it will cause heating (Cossitt, 1957). More important were the exceptions pointed out by McLemore (1961 and 1975) and Barnett (1976a and 1976b)--that there are differences in storability among southern pine species.

At this point, a brief discussion of cone moisture may be appropriate. Data derived at the Seed Lab showed that the moisture content of green pine cones was nearly 50 percent by the end of August. The moisture content decreases with approaching maturity, and at a specific gravity of 1 (water flotation), the cones are collected. At that stage of maturity, their specific gravity is about 0.80. Their moisture content is about 20-25. Because there is as much as 6 weeks variation in cone ripening, it is likely that the average moisture of cones at collection is nearer 30. They must be dried to about 10 to effect maximum cone opening. The drying process occurs by evaporation of moisture at the cone's

surface. Thus, if there is air movement, as on the tree, evaporation occurs constantly. Green cones placed in burlap sacks are held in an atmosphere of high moisture because of the hygroscopic nature of the woven material. Therefore, drying is reduced to brief spurts as circulating air moves moist air away from the bags. When air movement is reduced, so is the drying process. Although the moisture levels may vary among species, the process is the same for most cones and fruits.

The moistness of freshly collected cones makes them extremely vulnerable to the adverse effects of heat and mold. Therefore, the quicker the seed can be removed, the better the chance of maintaining high viability.

Refrigeration of cones or fruits reduces immediate fungal problems, but because the moisture content is not reduced the problem remains. Eventually, fungal growth will be evident even in refrigeration.

Based on this knowledge, we can make some general comments on storing and transporting pine cones and fruit:

1. Don't pile cones or fruits at collection point.
2. Transport as quickly as possible.
3. Refrigerate long distance shipments.
4. Maximize air exchange around fruits.
5. Process as soon as possible. When not possible, circulate air around fruits.

6. Store fruits in layers not exceeding four cones in depth, at the processing plant.

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ARTIFICIAL RIPENING TECHNIQUES  
FOR LOBLOLLY PINE CONES

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Abstract.—Satisfactory seed yields can be expected from loblolly pine cones collected from 3 to 5 weeks prior to their expected ripening dates if proper after-ripening techniques are used. Collections from a seed orchard should be scheduled on the basis of the expected clonal ripening sequence in order to maximize efficiency.

The collection of loblolly pine cones in production seed orchards presents many challenges to seed orchard personnel. Loblolly cones cannot be collected by a tree shaker due to their short, tough peduncle (cone stalk). Cones are usually concentrated high in the trees on inaccessible branches. The use of platforms, ladders, bucket trucks and homemade lifts is slow, expensive and dangerous.

The most effective way to maximize seed yields is to collect only completely ripened cones. In this way, cones will open fully and seed quality should be at a maximum. Unfortunately, in large orchards, it is impossible to collect all the cones between the times of cone ripening and seed fall. For these reasons, early cone collection is attractive as a means of extending the collection period.

#### CONE AND SEED MATURATION

One of the first investigations of early cone collection was a study of Virginia pine in Maryland (Church and Sucoff 1960). In that study, seed viability reached 45% eight weeks prior to natural cone opening. A later study by Fenton and Sucoff (1965) confirmed that in the same area seed germination is possible 10 to 12 weeks earlier than natural seed fall.

Loblolly seed from central Georgia has been determined to be viable as early as the end of July <sup>2/</sup>. One seed lot with 3% germination initially improved to 100% when dried to 8-9% moisture content. Apparently, the drying procedure compensated for the natural process of maturation.

#### ESTIMATION OF CONE MATURITY

The classical measure of cone maturation is specific gravity. As the process of maturation proceeds, cones on the tree lose moisture and their specific gravity falls. Wakeley (1954) advised picking loblolly cones when the specific gravity drops below .89. A convenient method of checking is a flotation test in SAE 20 motor oil <sup>3/</sup> or a mixture of 4 parts raw linseed oil - 1 part kerosene. At this stage of maturation, most cones will fully open and seed viability will be high.

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<sup>3/</sup> Not all SAE 20 motor oil has a specific gravity of .89.

Although specific gravity is not always a reliable prediction of the opening of early - collected cones, some geographic trends have been noticed. For example, cones from the southern Atlantic coastal plain opened at a higher specific gravity than those from more northern coastal areas (Kundt and Lantz 1968). In this same study, early collected cones from coastal areas opened at higher moisture contents than those from piedmont sources.

As loblolly cones ripen, they change from a dark green to a pale straw color. This color change can be used as an index of maturity when the observer has had considerable experience with specific clones. However, the great amount of variation in color between clones precludes the use of color standards which can be used with a number of different clones.

An association between the color and texture of loblolly seeds and their maturity was made by Waldrip (1970). As the seeds in his study matured, their seed coats become progressively darker and ridges become more pronounced.

#### AFTER - RIPENING TECHNIQUES

The suspicion that viable loblolly seeds could be collected as early as July and August led to many empirical studies of early cone collection in the early 1960's. Many of these attempts met with frustration as mold infected the green cones and case hardening prevented seed extraction.

Members of the North Carolina State University Cooperative Tree Improvement Program investigated several after - ripening techniques that indicated promise in the early 1960's. A study by Kundt and Lantz (1968) involved 3,744 early collected cones from 10 seed orchards located from Alabama to Virginia. Treatments ranged from immediate kiln drying through varying moisture regimes to complete immersion in water.

The most favorable method found for after - ripening loblolly cones was storage under burlap bags which were kept continually moist in an outdoor, shaded location. Using this treatment satisfactory cone opening was obtained from cones collected during the last week of August. The earliest collection with satisfactory seed germination (84%) was a group of 5 clones collected from a seed orchard near Georgetown, South Carolina on September 5. While some clones did not achieve 80% germination until October 4, the majority of clones from eastern North Carolina orchards reached this level of germination when collected on or after September 25.

The conclusions of this study were that some clones from loblolly seed orchards could be collected from 2 to 3 weeks earlier than oil flotation tests indicated. A cool, moist, shaded after - ripening period was essential for adequate cone opening.

The importance of moisture in the after - ripening process was also noted by Waldrip (1970) in a study with cones collected in central Georgia. The collections covered the period from September 7 to October 17. Treatments included 30 days of storage at room temperature with no supplemental moisture; 15, 30, and 45 days of storage at 38°F with cones covered by damp sphagnum moss; and 30 days at 38°F with the base of the cone imbedded in moist Kimpak.

The results of Waldrip's study indicated that cone opening was satisfactory when cones were collected after September 18; with a specific gravity of 1.0 or less (water flotation); and 30 days or storage in damp moss at 38°F, followed by extraction with heat. All storage treatments improved germination significantly over non-storage treatment. The best storage treatment in terms of germination was the 72°F storage for 30 days. Early collected cones with this treatment did not open well however.

Waldrip's study also indicated that cones with a specific gravity above 1.0 require good air circulation while cones with a specific gravity of less than 1.0 are ripened better with cool, damp storage. (It is suspected that mold was the reason for this statement). It was also stated that fluctuating moisture conditions would probably be more effective for cone opening than a constant moisture regime.

Studies by the Virginia Division of Forestry over a 2 year period indicated that about 1/3 of the loblolly clones tested can be picked 5 weeks early with proper after - ripening techniques (Wasser 1978). The remaining clones can be picked 3 weeks early. The after - ripening techniques consisted of cones placed in burlap sacks, stored in a lathhouse under 50% shade cloth, watered daily and turned weekly. Starting in early October, the watering was decreased to once a week.

Extraction was done with a crop drying system for 48 hours in late October. A second extraction was done to estimate the additional recovery of seed possible. It was estimated that 82% of the seeds were recovered in the first extraction and 18% in the second extraction.

#### VARIATION IN CONE RIPENING AND SEED YIELDS

The tremendous amount of clonal variation in phenology and cone ripening in loblolly seed orchards is well documented (Kundt and Lantz 1968; Wasser 1967; Zoerb 1969). In addition to the management problems created, these clonal differences in cone ripening must be considered in cone harvesting and after - ripening procedures.

The time interval between the ripening of the earliest and the latest clones in a loblolly orchard may be as long as 2 months (Zoerb 1969). It has also been observed that cones from the early ripening clones may take much longer to open than those from later ripening clones. These relationships play an important role in extending the cone collection season.

An additional source of variation in the production of seed orchard seed is the variation in seed yields by collection date. The seed yields from 2 of Weyerhaeuser's North Carolina loblolly orchards illustrate both the variation in seed yields between clones and the change with time (figure 1).

The Weyerhaeuser cone collections were scheduled by individual clones from September 13, 1978 to October 23, 1978. Cones were packed loosely in burlap bags and placed on wooden storage racks, exposed to the weather, including direct sunlight. Processing was started on November 10, 1978 with the earliest collections receiving about 6-8 weeks of after - ripening.

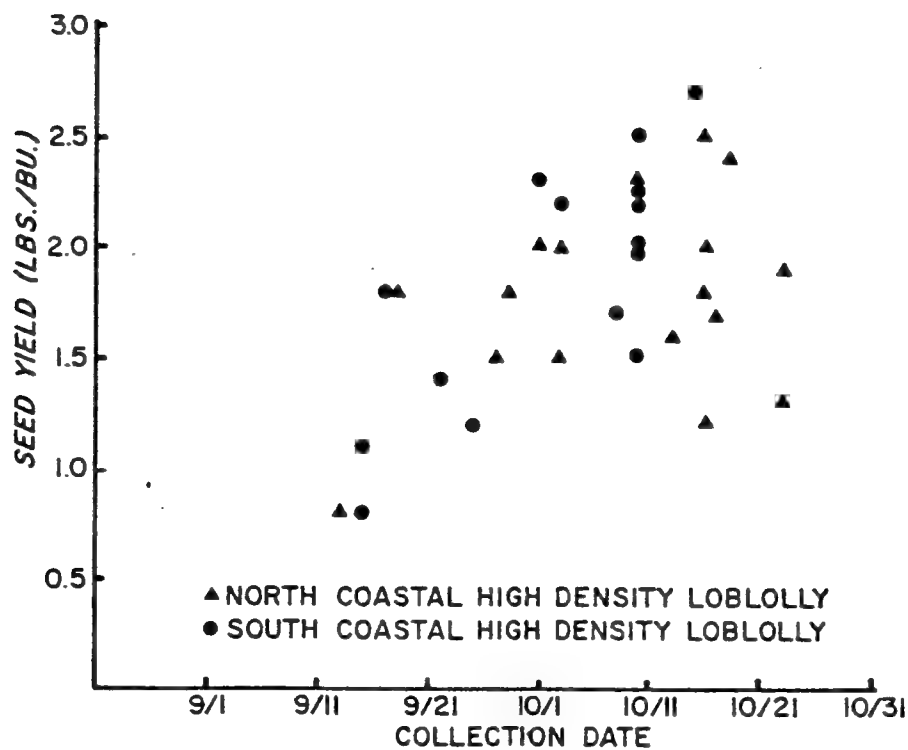


Figure 1. Weyerhaeuser clonal seed yields by collection date. (Each data point represents a clonal average).

It is apparent that in this study as well as in a study reported by McLemore (1975), seed yields increased with later collections. It also appears that the amount of variation in seed yield increased with the later collections. The effect of the weather on this relationship is not known.

Seed yields overall were exceptionally good. All but 2 clones produced more than 1 pound of seed per bushel of cones and 1 clone produced a record 3.7 pounds per bushel. Overall seed yields for coastal orchards averaged 1.7 pounds per bushel. These results reflect a combination of efficient seed orchard management, effective cone harvesting and after - ripening techniques and a good seed extraction operation.

#### CONCLUSIONS

After - ripening techniques are an effective means of extending the cone collection season in loblolly pine seed orchards. Maximum harvesting efficiency requires the scheduling of cone collections in the predicted clonal ripening sequence. Although weather conditions may accelerate or delay ripening, the relative sequence of clonal ripening is very similar from year to year.



Specific recommendations for after - ripening techniques include:

1. Record the ripening sequence of all clones each year in order to establish a pattern.
2. Set up an after - ripening system which includes partial shade, good air circulation, and a water source. Although data is lacking, it would appear that a wet - dry cycle is favorable for good cone opening.
3. Systematically examine the cones for mold. Good air circulation and single layers of burlap bags on racks will help to reduce mold problems. Bags should never be more than half full.

Although fungicides have not been adequately evaluated for mold control on cones, it is possible that they might be useful. Perhaps dipping the burlap sacks in fungicide solution would be effective.

4. Seed quality should be carefully monitored by sampling at different stages in the after - ripening process. Although only slight losses in viability have occurred following early cone collection and storage (Barnett 1976), the potential for fungal damage is always present in this type of process (Miller 1979).

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